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I. SECTS AND SCIENCE.

THE land is full of disputes about sectarianism, denominationalism, religion, and materialism, literature, and science. There was a time when we had only two choices—to believe as Romanists or Anglicans; gradually we rose to have three, and Churchmen and Non-conformists took each their place; but now the busy brain has split these into numerous parties, and the whisperings and breathings of history have passed through the stage of the Æolian harp, and risen into violent storms threatening to destroy. Galileo's reputed muttering is becoming one of the most powerful voices of modern times, and the terrible "still it moves" is, in some form or other, heard from the mouths of most scientific men, who threaten to make science a power in every department of government, and, as some of them suppose, in all things relating both to thought and action. We do not take the latter view, but we take (perhaps not all) the former. We do not believe that physical science will ever govern the whole world, or the lives of the best of men; we do not even believe that moral science will rule paramount, or any science whatever that we can understand, because we consider that there will be a movement forwards, always in advance of our reason. But no man who knows the force of natural truths can help distinctly wishing that man may rapidly be taught to see their beauty, and gain the power that lies within them to aid him in the labours of his life, as well as in all his thoughts and aspirations.

The hopes of humanity from natural science are high; and when we think of our ancestors wending through the rainy, roadless, and mud lands of Europe, with straw for their boots and their stockings, and of ourselves rushing in an express train, sleeping in an apartment heated with hot water, we have a foundation for our confidence. When we see the laws of health setting kingdoms in motion to stop by united action the plague nursery among the pilgrims to Mecca, and when we learn that civilisation may be promoted

amongst the inhabitants of the wildest districts, where communication by messengers is scarcely possible, a simple wire doing all the work, we begin to see that the great cities of the world are no longer to be the producers of invention, and the *foci* of movement, and that we may have these scattered over the world without the disadvantages of inordinate congregations of men.

We have the fullest faith in science, a faith which does not waver, but at present we shall not dilate upon it; we say it that we may more clearly object to that class of men who see also its beauty and its power, but have lost the knowledge of the fact that much beauty and power existed before it. We have a large class of men who know more or less of physical science, and having seen the exactness of many of its conclusions, look to its methods for deciding all questions arising among them. It is always amusing to see people with very narrow views—they are generally very exact within certain limits; very certain, and very determined; very active, and often very successful, because they see their end near, and have not far to go. But when we find that their certainty is akin to that of the boy who is sure that he will find the rainbow if he only gains the other hill, and when the means of attaining a great object are as small as the child's arms that stretch out for the moon, knowledge of failure is the only success to be hoped for, a knowledge that broadens.

Our novels are full of descriptions of the small sectarian who preaches his little belief in his little chapel, with little knowledge, to a small congregation; but we are not sure that such men are the narrowest. Our novels have not yet sought out the preachers of mere physical science, and explained the foundation of the truths so scantily dealt out by them. They have not yet learnt to laugh at a national faith consisting of geology, or astronomy, or mineralogy, or pictured the consolations of the soul fed upon chemistry and physics, or they would have shown how little these are able to fill the circle of all man's rational hopes, or even daily needs. The merely scientific man, whilst enlarging his own importance and diminishing that of others, forgets that he is simply doing that which he objects to in others, and is forming a sect, and as such, therefore, we paint him in our minds; and as we desire to be above mere sectarian views, we refuse to unite with him alone, but shall receive him as one of the many who preach to us daily their partial truths, and receive from us our partial assent.

It is our part to advocate the views of men of science so

far as to bring science into its proper position in deciding truth whenever it can decide, but in speaking to the young we must not be purely chemical or physical, we must remember to be men, and must contribute to education in such a way as to educate the young to become men also. We shall advocate no little doctrine of Little Bethel, or of Romanism, Anglicanism, or scientism, as the only sections in which truth are to be found, but we hope to be ready to receive it wherever it is. Devoted to physical science as we are, we should not suppose our sons to be educated by being continually in a scientific laboratory, any more than an intelligent minister of any religion would consider his children to be educated by having them confined solely to listen to the teaching from the pulpit.

The struggles of mankind to obtain knowledge have been long and various, and he only is educated as a man who has followed them with sufficient attention to enable him to learn the actual standpoint of humanity, and the method of arrival. We can imagine our ancestors coming out of the distant East, moving forward slowly towards Europe with their flocks and their wealth, staying centuries occasionally at a place because they liked it, and had few enemies, and then moving along to some more favoured spot when disturbed or becoming greedy of greater gain. Let us imagine one of them who knew of the whole road, and at last arrived at the rich lands of Normandy, or obtained the full throne of England, boasting of the steps he had made, and ridiculing the stupidity of his forefathers, perhaps Odin, who was satisfied with poor plains in the North of Europe, or some cold spot approaching to Scandinavia. It would be an empty boast that he was greater than Odin; the triumph may be gained by the least able if he only lives at the proper time for it. We hear our students of the present criticising the past with a lightness which is productive of smiles, and some of our scientific men are so elated with their position as the latest men upon the earth, that they would readily break off their connection with the past, and live as the men in whom wisdom had first grown. But they also will move to the past, and their wisdom will be part of the long line, and they will be mere individuals in the endless caravan which stretches from the beginning into the future. It is only when we consider the littleness of each that we can become truly wide or broad in our sympathies.

It might be worth while to enquire whether as a nation we are becoming so, or not; probably we are broadening in

some respects and narrowing in others. If the individual is giving way to his littleness, is thinking too much of his own gains and his own happiness, if he is forgetting the past in the foundation of the present, and is weakening thereby the foundations of the future to be built on it, it is for the nation in its collective capacity, or for the wiser men, to lead the young. This must be so done that they shall not enter active life as the inferior animals do, with their mere instincts and unaccumulated knowledge. We see great danger of the latter; we see more than danger, we see men growing up in this condition of want of early experience to an extent greater than can be viewed without objection, although absolute loss is impossible in our busy world, where the most ignorant uses modern arts of civilisation. There is evidently a strong party in England determined to break off from the remotest contact with the traditions of the great eternity behind us, as they have ceased to think of that which is before us. They are men of observation mainly, and they have driven their principles to an extreme, and attempted to make their observations on that which is not present. The type of such men is easily seen in the less civilized state: in mercantile life they are men who drive little bargains, look after little gains, think a bird in the hand is worth two in the bush, and with a firm grip hold enough of the goods of the world to enable them to live without fear of starvation; wider minds come into the same field and become great merchants. It seems to us that we can detect the same or analogous smallness in the sayings and doings of those who learn only the practical arts of the scientific men of modern times, dealing only with physics. They have one mode of thought, clear, sharp, and beautiful, but they fail to look with the broad views of humanity, because they have not learnt how humanity thinks and feels; still they are often the cleverest and most inventive of men, and humanity will thank them for their discoveries, and by adopting them will give them the width of nature. This latter our great institutions, our universities, ought to look after; it is for them to think on every side of a question, and to reject nothing that humanity holds dear. Clearly, however, the small dealer has instilled into us many of his principles. We seek too exclusively to teach a boy that which will enable him to earn his bread; we do as the hens do, and set before them a few crumbs until they can find enough for themselves—we feed them as birds do their young, with worms, or with game, until they can fly after more; only a few can be taught to

fly about the heavens for joy, singing with the lark, or rolling like the tumbler. These are like arts that bring no bread, but typify leisure, grace, and overflow of life, thought, and feeling.

The wise men we ought to find in our universities. They must keep the links of humanity together; they must prevent us from looking at subjects from one point of space or time merely, and enable us to view them from every good loophole, even out of almost forgotten eyes of Pythagoras and Zoroaster, and others, up to our time. And when the world laughs at such names, as unfit to teach us to make a thousand pounds a year or a week, we shall say "These men saw a world that we do not see; and when our own view is rather confined, we may see it profitable to use their vision, and claim for cultivation the fields they discovered."

The universities must be broad, or why should we call them universities? Narrow them, and in that proportion you make them sectarian. They certainly began with very limited views, but they have gradually grown, and one or two include nearly all the circle of human thought. None, however, include actually the whole. When London University rose and excluded the religious element, that was a decided step in the formation of a sect. It limited the universality, so to speak, and although it may be said nominally to have excluded only one branch of mental activity, we must remember that the branch was to the most of the world the most important, and in early times the only branch taught at seminaries rising to universities. It was a new step separating, in a prominent manner, religious and secular education. That separation is going on still more, and without objecting at all to it we must not forget the importance of the era passed. We had at once two sects—two divisions. Some persons will say that these were not two sects properly, because they attended to different subjects; but probably no persons will say that they were not two sects in every sense but the name. There was a desire to separate from the religious question from a dislike to it, and this is already a sectarian element in society; no man can differ from society without being sectarian unless he is perfectly right, and when he is so we shall cease to give him any trifling name. But to separate from religious bodies because you adopt other religious opinions and make converts is to form a sect in the eyes of all; and to separate because you object to all religious opinions is equally to form a sect, unless you can show

thoroughly that you were absolutely right. Even then you become a division of society, and this division, begun in Gower Street formally, has spread over the land, so that we have the sect of physical science containing many men to whom the spiritual in religion has positively no meaning at all—being the fantastic creation of the brain. We do not say that all this is owing to Gower Street. It took a shape there, and did good. Now it is not here that we intend to give our opinion on the subject; we number both classes among our intimate friends, and we have our opinions; but at present we say that the movement was sectarian. Sadducees always have been reckoned as belonging to a religious sect, although denying that which to many men is the foundation of a religion. In other words, the study of merely physical science produces a class of men that influence the religious belief of a country and divide it.

Are we to decide which sect we shall belong to, and whether Oxford and Cambridge or the London University are to rule over the country? This would, in our opinion, be a backward step whichever we chose. Science is growing so rapidly that we cannot tell the limits to its power; we must give it free scope, we must allow its reasonings to have their full weight, and we must learn to give matter its full importance in our reasoning, seeing the great position it holds in creation.

It is our belief that these great representatives of human thought and progress, the universities, are essential to us in some form or other; it is difficult to tell what is the best form, but we may fairly decide which of the two classes of institutions is the widest or broadest. If we look at Oxford and Cambridge, or the universities in Scotland and Dublin, we find that, although beginning with teachings relating to the spiritual nature of man, they gradually have included more and more the physical.

The newer university, that of London, excludes the former. The other universities seem desirous to increase their professors in every direction; that of London excludes at least one direction. We therefore simply conclude that the older universities have a greater breadth; or look over more of the field traversed by man, and do not exclude either class of knowledge. They have certainly their opinions on one branch, but their studies comprehend both.

Be not surprised, therefore, if we look at the London University as sectarian in its views, and as fostering a sectarian knowledge. It must, in a sense, stand somewhat in the same position as the Methodist College or the

College of Independents, and partake of denominationalism. The result is in our opinion decidedly so. Men as a rule turn out to be what they are taught to be.

Are we therefore to blame the one or the other? Certainly not the old for being wide in theory. It will be said that this is only in theory, and that in practice their teaching is narrow, and that in former times it was still narrower, and therefore the London University was called into existence. This was partly true, and therefore we should be sorry to see it otherwise, at least for a while; this reasoning, however, simply shows that the new institution was supplementary, and did not even pretend to the greatest breadth. The spirit of this university seems to continue unchanged, and there is a growing tendency to the cultivation of science only. The exclusion of Greek from the necessities in the matriculated examination is a step in a similar direction, and one most resolutely fought for. The tendency is to the cultivation of the present. It is the same spirit that stimulates the manufacturer to despise science, and to make his son learn by apprenticeship the thumb-rules of his art, although for professions no university is so strict in encouraging true scientific principle. For this the nation owes it much.

Is it to the same feeling in the nation that we are to attribute the proposal of the premier to found a university which should not teach metaphysics? The occasion of the proposal would lead us to suppose that the cause was quite different; but the time at which it took place, and its associations, would lead us to think that he was moved by the spirit of the age, pressing in directions foreshadowed, but unseen except to a few.

This may be the case, and unknown even to the author himself, who certainly is not a man to be guided by merely material considerations. It comes at the time of the exclusion of Greek, and with the proposal of one examining board.

We are glad that there are the old and broad universities ready to receive all knowledge within them, lax sometimes in their rules, lax in their examinations on some points, but minute in others—like scholars careless in many things—but excessively careful of the points they study. The new comes out with business-like habits, numbers its students like workmen in a mill, knocks off those that are not up to the mark, and promotes the best, ruthlessly but successfully making good men of business—a magnificent manufactory of professional men—journeymen in science.

Should we like all England to have one examining board, all Scotland to have one, all Ireland to have one? Why not all the nation to have one? If we knew the truth in perfection, we should decide that all the world ought to have one, in sections, according to convenience of management. But we have not attained to perfect certainty in many things, and we object to have the sons of England educated as if we had. We must have a choice. If a man is narrow in his views, or if he desires that one young man shall have a professional education for teaching a sect, he sends him—let us say—to the Methodist College, or the Unitarian Hall, or the exclusively religious teaching of the Anglican Church, or the exclusively scientific teaching of the London University; but if we wish him to learn the struggles of humanity for knowledge, and the width and breadth of the attainment, we send him to a variety of classes, such as may be found at some of the older Universities, which are keeping up, or attempting to keep up, with modern times, and without bigotry are allowing the establishment of as many professorships as money can be found to maintain.

Yet there are men that would make the whole education of the country sectarian, that would destroy Oxford and Cambridge, as distinct units, and make one examining board decide the education of all the country. We have heard of a bed of Procrustes, but this is the most severe yet known to us; we have heard of inquisitions and faith-makers, and bigots, but none of them have ever set themselves up more decidedly above all their fellow-men than such a plan would exalt the proposed powerful organisation. Freedom of thought would, as a matter of course, be curbed. We should have only one educated sect, only one direction given to the general bearings of the mind, although the studies would be various. These great bearings decide that which we call character in individuals, so difficult to explain but so decided in its effects. These inexorable examiners, who are precluded from judging of any but intellectual feats and feats of the memory, would decide the mode of teaching and the things to be taught, and the still less exorable council would appoint the men to examine. The unhappy school teachers over all the country would be obliged to teach up to one standard, instead of, as now, having a choice; and instead of that variety of thought out of which new combinations are formed, one universal sameness would dominate in schools also, which would be as void of light

and shadow as the universities—dreary and dull. The evil is already showing itself, partially because as concentration goes on sameness increases; do not let us increase the evil. The man who can examine the young men of a college in metaphysics long enough to influence much of the habits of the teachers who send pupils to the colleges, and long enough to accustom them to his text books, has a power over the generation coming such as no other man has. A Prime Minister is nothing to him, and all the powers in Church and State must eventually yield more or less to his authority, although they may not know it. The examiner eventually directs the leading minds. In them we must consider real power to lie. It once lay in the army, it once lay in the song-makers, some one says; it lies to a great extent now with the reasoners, in all cases where they do not oppose the men of business, and the choice of modes of reason is with the examiners.

The genius of this nation has arisen in a great measure from the diversity of its population; this diversity has produced difference of training as well as difference of constitution. One great difference, that of training, would be removed by the one university alluded to, a system which has never been shown to produce good results.

It is not merely that there is no competition allowed by it, although that may be a loss, but there is no diversity; and there is no true freedom of thought where there is no diversity; and above all, there is in the exclusive character of the intention no sufficient breadth.

As proposed in Ireland, the narrowness was such as to reduce it merely to a school of certain branches.

It is greatly to be wished that no such schemes may be attempted in England, and it is equally desirable that no experiments of this lowering character will be brought into Scotland or Ireland, but that we should retain our universities founded on the structures laid not merely by the men of yesterday or the men of last century, but the great of all centuries, so that we may have institutions in which the wisdom and science of modern times, the devotion of mediæval ages, the strength of Rome, and the thoughtful searchings of Greece shall be side by side with the spiritual character and the search for holiness produced and hitherto producible only by the teachings of the East.

II. ACTINISM AND MAGNETISM.

By MUNGO PONTON, F.R.S.E.

HOW slow have mankind been in searching for and ascertaining the causes of physical phenomena! How tardy their efforts to apply their knowledge to practical purposes, even where the ultimate uses have proved to be of the highest importance to the well-being of the human race! How many ages had elapsed before Franklin discovered the cause of electrical phenomena—before Volta found how electricity might be developed by chemical action, and before Oersted perceived the mutual relations of electricity and magnetism! Even after the finger had thus been, as it were, pointed to a practical application, how many years intervened before this last discovery ripened into the construction of the electric telegraph!

In like manner, how many ages had elapsed before Scheele discovered the actinic action of light in blackening the chloride of silver; and what a number of years has it taken to develope that discovery into the art of photography!

It seems wonderful that the attention of mankind was not earlier attracted to the action of the sunbeams in developing or altering colours, and that they were not led to investigate the cause of this curious phenomenon. It might have been supposed that a careful study of Nature would have led them to perceive it to be the energy of solar light that tinges the cheek of the peach with crimson, gives the apricot its flesh-like tint, imparts to the harebell its beautiful blue, paints the pansy with alternating brilliant yellow and deep violet, reddens the rose, and dyes the tulip with its richly varied hues. The first attempts at tracing the operation of the sunbeams in the colouring of flowers were made by screening the petals from the action of the light; but these experiments went no farther than to show that, in some cases, the petals do not acquire their proper hue when they are thus screened. The subject, indeed, was little studied until after the discovery of the actinic action of solar light on other substances. Even yet, one of the most remarkable cases of what may be termed natural photography is but little known. It is that of the beautiful bell-flower of the *Cobæa scandens*, which on the first day of its opening is of a pale-greenish white, but after exposure for two or three days to the actinism of solar light acquires

a rich purple. This actinic action on the juices of plants has not been deeply investigated, nor has it as yet been applied to any practical purpose.

Another example occurs in the animal kingdom. The common earwig, if reared in the dark, is almost colourless, being of a nearly uniform creamy white; but if it be subsequently exposed for some hours to moderate daylight, it will eventually acquire its natural dark colours.

It appears to be part of the wise dispensation of Divine Providence in the government of the human race, that the most useful discoveries should be made only after the exertion of a great amount of industry, applied with much wisdom and skill—and that, too, not by a single individual, but by a long succession of men. It is given to one to discover a principle, to another to take advantage of it for the attainment of some practical end, to a third, a fourth, and a fifth to make successive improvements in the working out of the principle, and in modifying its mode of action. Thus, Niepce first discovered the effects of light on films of bitumen; this result suggested to Daguerre the application of iodine vapour to produce on plates of silver a film sensitive to light, and the subsequent development of the image by mercurial vapour—a photographic process which bears the name of its inventor. It was Scheele's discovery of the action of light on chloride of silver, followed up by Wollaston, that led Fox Talbot to its practical application in obtaining photographic images on paper, and to his further discovery of the mode of producing a latent photographic image on iodide of silver capable of subsequent development by the application of a powerful deoxidising agent. These results paved the way for Archer, who availed himself of Schœnbein's discovery of soluble cotton or collodion to spread a film of that substance on glass, and charge it with iodide of silver, so obtaining a more sensitive and manageable medium for the reception of the latent photographic image, to be afterwards subjected to the action of a developing agent. Other and later labourers in the field have greatly improved on those earlier methods, until the taking of pictures by means of salts of silver and developers has now reached a pitch of perfection of which the earliest pioneers in the art had scarcely dared to dream.

To the lot of the author it fell to discover the photographic properties of the double salts of chromic acid when in contact with organic matter, and the curious fact that the disengagement of the chromic acid from the salt under the action of light, and its immediate re-combination with

the organic matter, operates in the latter a great change, rendering gelatine, albumen, and such like substances insoluble. It was reserved, however, for a succession of other labourers in the field to develop this discovery into the method of printing photographs in gelatine, impregnated with carbon and other pigments. Under the action of light, gelatine, charged with the bichromate of potash or ammonia, becomes insoluble by warm water in exact proportion to the degree in which it has been affected by the light. Hence, by spreading gelatine in plates of some degree of thickness on films of collodion, exposing these with their collodion side next the negative, and subsequently dissolving away the portions more or less unaffected by the light, pictures are obtained in relief. Of this property Woodbury availed himself to take metallic casts from those pictures in relief, and from these metallic plates to take impressions on paper in pigmented gelatine.

The utilisation of the original discovery has been recently brought to still higher perfection by its having been found that the plates of gelatine, thus impressed by light, may themselves be rendered directly available for obtaining impressions on paper in engraver's ink. Yet how simple the matter appears now that it is known! When on a plate of glass, previously coated with white wax dissolved in ether, there is spread a plate of gelatine charged with bichromate of potash and chrome alum, and when, after being allowed thoroughly to dry in the dark, this gelatine plate is removed from the glass, and placed under a negative photograph, wherever the light penetrates, the gelatine becomes, in a greater or less degree, not only insoluble in warm water, but incapable of imbibing moisture. But the parts thus acted on by light can, with greater or less degrees of readiness, receive engravers' ink. Those portions which have been most hardened by the light will receive the stiffest ink; those which have been but partially hardened will take on the ink only when it is more or less diluted; while those portions which have escaped the action of the light, and have become moist (but only very slightly swollen) from imbibing water, refuse the ink altogether. In this manner every gradation of shade may be given to the impression produced from the gelatine plate, and it is said that as many as 1500 impressions may be taken from the same plate, direct pressure being employed. This last, which is the most perfect application of the double salts of chromic acid to photographic purposes, is due to the laborious industry and skill of Ernest Edwards.

The two last-mentioned processes, in both of which the copies are multiplied by purely mechanical means, afford the most expeditious and economical methods of attaining that end. The copies thus produced, however, are not strictly speaking photographs; while, to an artistic eye, they are inferior in delicacy to those obtained from the primary negative by direct actinic action. Much skill has accordingly been directed towards perfecting the processes by which the latter sort of pictures may be produced. It was first pointed out by Mr. Blair, that the best mode of bringing the actinism to exert its effect on the pigmented gelatine, is to make the light act from behind, so as to allow its hardening influence on the gelatine to penetrate to different depths, according to the lights and shades of the negative. Hence arose the practice of taking the impressions first on paper coated with pigmented gelatine, and thereafter transferring it to white paper coated with simple gelatine. Very good effects were obtained in this way, but the pictures laboured under the disadvantage of presenting the image reversed as respects right and left.

To rectify this reversal, recourse was had to the method of double transfer, as practised by the Autotype Company. In this process the picture is first transferred from the black bichromated gelatinised paper to a plate of zinc, and when the picture has been fully developed by washing the plate with luke-warm water, it is transferred from the zinc to white gelatinised paper, on which it appears rectified in position. An improvement on this method was subsequently effected by Mr. Johnston, of the Autotype Company, who discovered that, by coating white gelatinised paper with a film of wax and grease in certain proportions, the image, if first transferred to this paper, may be re-transferred from it to another piece of white paper, prepared with a strong solution of simple gelatine. By this plan, not only is the picture rectified in position, but the pigment, by imbibing a small portion of the wax and grease, becomes assimilated to engravers' ink, and adheres firmly to the paper. The brilliancy of the picture is increased by washing it with benzine. For the use of amateurs this last mode of printing in carbon is the best as yet devised, and it reflects great credit on the skill of its inventor.

In copying portraits, the author has obtained peculiar and striking effects by the following method. The portrait should for this purpose be taken with a dark background—that of the negative being nearly, though not quite, transparent. The bichromated black gelatinised paper is to be

exposed under the negative for three or four times the period required for an ordinary picture. A plate of glass, thoroughly cleansed, having been gently warmed, receives a thin equable coating of Sœhnée varnish. When this is dry, the picture is transferred from the black gelatinised paper to the glass plate, under luke-warm water in the usual manner. The picture is then to be washed clean, and allowed to dry thoroughly. A margin of very thin paper having been applied all round it, a second very clean thicker glass plate is to be laid over the picture, and carefully cemented to it all round the edges. The picture is thus enclosed between the two plates. The back glass (the thicker of the two) must then be coated with Brunswick black all over the background of the picture, the outlines of which must be carefully traced, so that no light may penetrate between the picture and the background. When the black varnish is quite dry, the picture is to be placed at an angle of 45 degrees, with a piece of mat gilt paper below it. When the transparency is thus viewed by the light reflected from the gilt paper, it presents the appearance of a bas-relief. This effect is so decided, that the spectator can hardly persuade himself that he is looking on a flat surface.

While the attention of investigators has thus been for a considerable number of years past directed almost exclusively to ascertaining the best means of rendering the actinic properties of light available for practical purposes, and rightly so, it is not well that the theoretical questions connected with actinism should be entirely neglected; for a thorough search into the principles and modes of actinic action is the most promising way of arriving at results which may eventually prove of further practical utility.

One of the earliest and most interesting questions which presented itself to the inquiring mind, was the possibility of explaining actinic action in accordance with the principles of the undulatory theory of light. In a former work by the author, the first edition of which was entitled "The Material Universe," and the second was (much against his wish) entitled "The Great Architect," he indicated the manner in which the formation and subsequent development of the latent photographic image, both in the process of Daguerre and in that of Talbot, might be explained agreeably to the undulatory theory. A further development of his views was subsequently published in "The Engineer," and again briefly re-stated in the notes of his more recent work, entitled "The Beginning, &c." But as his ideas have thus

been brought before the public in rather a piecemeal sort of way, it may not be deemed amiss that they should be here presented in a more regular and condensed form.

The duality observed in all electrical and magnetical phenomena, whether paramagnetic or diamagnetic, raises a strong presumption that there is in nature a *somewhat* to which this dualism is due. The remarkable circumstance that the magnetic influence, with its duality of manifestation, passes through the free ether, renders almost compulsory the inference that it is in this subtle medium that the origin of the dualism is to be sought. It is well known that there is a remarkable connection between the earth's magnetism and the solar spots, and that all magnetic observatories in our globe have been affected by certain sudden luminous flashes which have been observed in the solar photosphere. There can, therefore, be no doubt of the fact that the magnetic influence does pass through the free ether, and that magnetic dualism is thus wafted onwards like luminous waves through the ethereal expanse. Now it is almost inconceivable that this should happen unless there were some intrinsic dualism in the ether itself—unless, in short, it were composed of two fluids, which, like the nitrogen and oxygen gases of our atmosphere, are mechanically alike, but chemically different. It is needful to suppose them to be mechanically alike—both perfectly elastic fluids, and that, on their particles being set a vibrating, they vibrate in the same times, and that these vibrations are wafted onwards in similar waves of definite lengths. At least, there have not yet been distinguished any phenomena from which it could be inferred that the supposed two fluids differ from each other in their mechanical constitution in any appreciable degree. But it is equally needful to suppose these two fluids to differ from each other in their relations to the molecules, ultimates, and atoms of bodies endowed with the energy of gravitation, of which the ethereal fluids are themselves destitute; for it is only by such differences that the existence of two ethereal fluids can be established.

Waiving for the present the question of the relation of the duality of the ether to that of magnetism, and regarding meanwhile the former as merely a convenient assumption, let us, by means of it, endeavour to explain actinic action in the case of iodide of silver, and in particular to account for the formation of the latent image, and its subsequent development.

Let it be granted that each molecule of the iodide of

silver consists of an ultimate of silver, retaining by a strong attraction, in close proximity to itself, an ultimate of iodine, there being, however, at their nearest points, a minute space filled with the luminiferous ether in a highly compressed condition. Let it be further assumed that, in this interval, the two ethereal fluids subsist in a state of partial separation—the one being accumulated next the silver ultimate by reason of its being less repellent towards silver, the other next the iodine ultimate by reason of its being less repellent towards iodine. Call the former of the two ethereal fluids parargyrine, and the latter pariodine. Suppose that, in the system of luminous waves in a beam of light approaching this molecule, there are certain of the waves whose vibrations are synchronous with those which the silver ultimate tends to assume, and certain others whose vibrations are synchronous with those which the iodine ultimate performs in its tremors. The result will be that the silver ultimate will begin to vibrate against the iodine ultimate, and the two will alternately approach and retire. This, however, they cannot do without promoting a re-admixture of the parargyrine with the pariodine in their normal proportions. Such a re-admixture again cannot take place without weakening the attraction between the silver and iodine ultimates; for the silver ultimate begins to be urged by the repulsive energy of the pariodine, which is for it greater than is that of the parargyrine; while the iodine ultimate becomes exposed to more of the repulsive energy of the parargyrine, which is for it greater than is that of the pariodine. The consequence will be that, at the moment when by the vibration the ultimates of silver and iodine are farthest apart, the weakening of the attraction between them will be considerable. If now there be introduced another chemical molecule or ultimate having a strong attraction for the iodine, the probabilities are great that, at the moment when the vibration attains its extreme amplitude, the iodine will permanently leave the silver, and attach itself to the introduced molecule or ultimate for which it has, at that particular moment, a more powerful attraction.

On this general principle may be explained the development of the latent image, both in the case of the Daguerreotype, and on that of the collodion film. In either case it is needful to assume that the vibrations established by the action of the incident light continue for a considerable time after exposure.

In the Daguerreotype, the effect of the light appears to

be the disengagement of the iodine from the ultimates of silver near the surface, where the vibratory action is greatest—so allowing it to penetrate inwards and attach itself to those silver ultimates, which are less agitated by the motion. The iodine thus, as it were, eats its way inward, leaving behind it ultimates of silver more or less disengaged. Accordingly, when the plate is exposed to the action of mercurial vapour, the ultimates of mercury attach themselves to those disengaged ultimates of silver, forming with them a white amalgam, which constitutes the lights of the picture—the unamalgamated parts of the silver forming the shadows; while the unaltered film of iodide of silver is removed by the hyposulphite of soda.

The latent image in the collodion processes presents two cases—the one that of the wet film, the other that of the dry. The case of the wet film resembles that of the *Daguërreotype*. The silver ultimate and the iodine ultimate, which it retains near it by its attraction, begin to vibrate under the stimulus of the incident light. The *parargyrine* and *pariodine* in the intervening space are thus forced to intermingle—so weakening the attraction between the two ultimates. This condition continues for a considerable time after the stimulus of the external light is withdrawn. When a developer is applied, it takes advantage of the moment of greatest weakness, when the ultimates of silver and iodine are in the course of their vibration farthest asunder, and it effects their separation, the iodine combining with the developer, while the silver resumes the metallic form. The deposit of silver in this case constitutes the shadows of the picture when it is viewed as a transparency, and it is then accordingly negative; but when the picture is viewed by reflected light with a piece of black velvet behind it, the deposit of silver forms the lights of the picture which is then positive, and such are some of the most pleasing photographs.

When the collodion film is dry, again, it requires more applied energy to establish the vibratory condition as between the silver and the iodine ultimates, owing to the rigidity of the film; and for the same reason the vibrations are probably arrested the moment that the stimulus of the external light is withdrawn. But the attraction of the silver for the iodine has been permanently weakened through the action of the light, by reason of the readmixture of the *parargyrine* with the *pariodine*, in the interval between them, resulting from the vibrations. Hence, at the moment of the arrest of motion, the ulti-

mates of silver and iodine are farther asunder, in the case of those which have been exposed to the light, than they are in the case of those which have not been thus stimulated into vibration. Accordingly, when a developer is applied, even a very long time after exposure, decomposition ensues and silver is precipitated.

When ozone is applied after exposure and before a developer, it prevents the action of the latter. For the attraction of ozone for silver is powerful, and uniting itself to that of the iodine, it prevents the silver from being reduced to the metallic condition by the developer. Or perhaps it may neutralise the action of the latter, by supplying it with something which it prefers to iodine. The vapours of chlorine, bromine, fluorine, or iodine, applied after exposure to the light, would probably in like manner prevent the action of the developer.

On the other hand, it is well known to photographers, that the presence of a small quantity of free nitric acid greatly helps the action of light on the iodides, chlorides, and bromides of silver. It is not difficult to discover the part which this free nitrate performs. Confining attention to the case of the iodide of silver, with a slight admixture of the nitrate applied to the collodion film, and exposed while moist to the action of light, we must suppose that, while the silver and iodine ultimates vibrate against each other, a similar vibratory condition is established as between the ultimate of silver, and the molecule of nitric acid with its combined molecule of water. Now in the agitated condition of these substances, the iodine may momentarily be brought more within the attractive influence of the constituents of the nitric acid than of the ultimate of silver, and may form temporary unions with those constituents—hydriodic and iodic acids, and iodide of nitrogen in small quantities; while a portion of the oxygen of the nitric acid may temporarily become more intimately engaged with the ultimates of silver. If a deoxidising agent be applied while this state of affairs subsists, the oxygen will be easily disengaged from the metallic silver—the iodine becoming otherwise permanently occupied. In the case of the dry collodion film, again, the interchange of the iodine and the oxygen may become more permanent; so that at whatever distance of time the developer be applied, it has to withdraw only oxygen, not iodine, from the silver. The cessation of the action of the developer, however, after a short interval, in the case of the moist film, seems to indicate that, when the vibratory action excited by the light ceases,

the oxygen and iodine resume their original positions and relations, so that all things return to the same condition in which they were before the film was subjected to the actinism of the light.

When chloride of silver is applied to paper, in conjunction with a little free nitrate for printing purposes, the nitrate greatly quickens the decomposition of the chloride. This acceleration can hardly be explained on any other supposition than that the agitation, established by the actinism, enables the chlorine to migrate from the silver to the constituents of the nitric acid—forming hydrochloric and chloric acids—perhaps also chloride of nitrogen, while part of the oxygen of the acid attaches itself to the silver. Hence the colour produced is no longer the purple of the pure chloride, but there is a large admixture of brown from the oxide.

In the case of the double salts of chromic acid, the separation of one of the molecules of chromic acid from the base takes place by the action of the incident light alone, without the aid of any developer, other than the organic matter to which the double salt has been applied. It results from the vibratory condition established in the salt by the actinism, which, as it were, shakes free one of the molecules of chromic acid, and allows it to combine with the organic matter. There is here no latent image properly so called; nevertheless in the case of black pigmented gelatine the image is, owing to its blackness, invisible. But it may always be rendered visible by immersing the picture, after exposure, in cold water for an hour or so, when the picture will be seen standing out in relief. The portions of the gelatine, which have not been acted on by the light, swell through imbibing the moisture, and that in exact proportion to the degree in which they were protected from the light's actinism. Those parts which have, by the action of the light, been made to combine with the chromic acid, cease to have the power of imbibing moisture and swelling under its influence.

Some of the metals, more especially zinc, silver, and magnesium, when used as electrodes, generate ethereal waves lying far beyond the limits of the visible spectrum, yet capable of exerting a powerful actinic action. Thus an object might be photographed by means of actinic waves wholly invisible to the eye. This circumstance tends to establish the supposition already propounded, that the vibrations set up by actinism must be very minute, and such as are likely to take place between the ultimate of

silver and the ultimate of iodine, rather than such as might be expected in the movements of the entire molecules of iodide of silver.

It will be perceived that it is only the latent image in the case of the iodised films, either in the Daguerreotype or collodion processes, that requires for its explanation the help of the assumption, that the ether consists of two perfectly elastic fluids intimately mingled together, yet capable of partial temporary separation. Should this same assumption be eventually found available for explaining the duality observed in the phenomena of electricity, paramagnetism and diamagnetism, the evidence in favour of the hypothesis will be greatly strengthened by the circumstance of its being thus found to render such aid in explaining a phenomenon so diverse from these as the latent image.

The facts that metallic zinc, when thrown into a state of heated vapour, generates in the ether waves which, though wholly invisible, yet exert much actinism, and that aluminium, under similar circumstances, originates invisible waves capable of exciting fluorescence, favour the idea that the influence of the solar radiation on the magnetic needle may also be due to waves which are in like manner invisible. Experiments have been several times made with the view of showing that the violet and ultra violet waves do affect the magnetic needle; but the results, probably owing to the difficulties attending the experiment, have not been decisive. It would not be easy, however, to account for the known effect of solar radiation on magnets—more especially the effect of solar spots—otherwise than by supposing that there are special waves of some sort that pass through the ether, and either excite or alter the magnetic condition. If such be the case, then will it be probable that, exactly as all bodies which receive an accession of temperature from the solar energy give it off again by radiation, even so all magnetic bodies receiving an accession of magnetism from the solar energies give it off again in a similar manner, propagating from themselves back waves having a great rapidity of vibration—too great to be appreciable by the optic nerve, but nevertheless capable of exciting or maintaining either paramagnetism or diamagnetism in other bodies. Nor does it seem to be improbable that, as in the case of fluorescence, in which there is a change in the rate of vibration operated by the action of the ponderable particles, there may be, in the case of the magnet, something similar. Magnetic bodies may have

their particles thrown into the state of magnetic or dualistic vibration by ethereal waves, which in other bodies would produce quite different effects, and may reciprocally produce in the ether back waves having the same dualistic properties.

The supposition that the ether consists of two fluids might throw much light on the magnetic condition. For it might be explained by supposing the fluids to become separated from each other in the pores of magnetic bodies to a much greater extent than in the case of other bodies—the separation taking place lengthwise in the case of paramagnetic bodies, and crosswise in the case of diamagnetic bodies, so that in the former all the atoms having an atmosphere of parargyrine are turned towards one end, and all those having an atmosphere of pariodine are turned towards the opposite end; whereas, in diamagnetic bodies, a similar arrangement subsists laterally. Any waves having their origin in ether, whose constituent fluids might be thus separated, would have a direct tendency to become double-sided—that is to say, in such a wave the particles displaced towards the one side of the line of propagation might at any given moment be all of parargyrine, while those displaced towards the opposite side of the line of propagation might at the same instant be all of pariodine. Nor does it appear impossible that, in a similar manner, there might be generated invisible magnetic waves, which should be polarised in opposite planes—those whose vibrations are performed in one plane affecting only the parargyrine: while those whose vibrations are performed in the opposite plane affect only the pariodine. The double-sidedness of the waves, however, seems to be a more probable explanation of dualism, as it subsists while passing through the free ether.

That the condition of dualism is actually transmitted through that medium, the connection between the solar spots and terrestrial magnetism seems to render it almost necessary to conclude. Were it not for that connexion, it might be enough to suppose that, in magnetic bodies, the tendency to a separation of the two ethereal fluids is favoured and augmented by a vibratory condition of the particles of the magnet; while in the case of the silver salts, the already existing partial separation of the two fluids in the interval between the silver ultimate and the other ultimate with which it is in combination, is neutralised by the vibratory motion. In the latter case, the vibrating ultimates are supposed to be very near each

other, and by their oscillations mechanically to mix the two fluids. But in the case of a magnet, the vibrating particles are farther apart, and the effect of the vibration seems to be to drive away the intervening parargyrine from one of the kinds of atoms of which the ultimate of iron consists, and the pariodine from another set of those atoms—so promoting the separation of the fluids.

The permanent condition of magnetism does not appear to be capable of explanation, except on the supposition that every such magnet has the power to convert invisible ethereal waves into magnetic waves. There is even in the dark a constant interchange of radiation between magnets and all other surrounding bodies. Now if magnetic, like fluorescent bodies, have power to alter the rate and character of vibrations communicated to their particles, it is not difficult to imagine, that what comes to the magnet as radiant heat, or light, or actinism, may in part at least be given off again as radiant magnetism with its concomitant dualism, and that what in other bodies serves only to maintain their temperature at a pitch corresponding to that of all surrounding bodies, serves in the case of a magnet partly to maintain its magnetism at a certain rate of tension.

Magnetism is quite as much an energy as temperature; nor does it appear more possible for a magnet to maintain its magnetism without a continuous fresh supply of motive energy, than for a body to maintain its temperature without a like supply. Moreover, as the motive energy of temperature is undoubtedly capable of being converted into the motive energy of magnetism, and *vice versâ*, it seems no more than reasonable to suppose this conversion to be in continual progress in the pores of a permanent magnet. Thus it appears unnecessary to look farther for the needful supply of motive energy which maintains permanent magnetism, than primarily to the ethereal waves transmitted from the sun, and secondarily to the continuous radiation emanating from all surrounding bodies. Doubtless a portion of this energy goes to maintain the temperature of the magnet; but it must be borne in mind that this temperature is nothing else than a certain amount of vibratory motion in the particles; nor does it appear improbable that such a vibratory condition cannot subsist, without tending to uphold the magnetic state, where it has been already developed. Such a degree of cold as would reduce this vibratory condition to a very low point would no doubt destroy, or at least suspend, the magnetism of a permanent magnet.

III. MAGNETO-ELECTRIC ILLUMINATION.

By WILLIAM CROOKES, F.R.S., &c.

THE progress made in electric illumination during its advance towards perfection has been several times recorded in the pages of this journal. In our first number, published nearly ten years ago, Dr. J. H. Gladstone gave a history of the early difficulties attending the introduction of the magneto-electric machine as a light-generator for lighthouse illumination. Two years subsequently, the present writer described Wilde's magneto-electric machine, and, after a further lapse of years, during which time no very important improvement in the industrial application of magneto-electricity has been recorded, another step in advance has been made which calls for detailed notice.

The chief difficulties in the employment of magneto-electric currents for industrial purposes have been their almost instantaneous character and the rapid alternation in their direction. The instrumental means necessary to seize hold of these rapidly alternating waves, and convert them into a more or less continuous stream of force flowing in one direction, are necessarily of a delicate character, and are easily put out of adjustment. This is easily understood when it is remembered that in the machine first tried by Mr. Holmes the rubbing surfaces were worn away in ten or twenty minutes. The Berlioz machine required for its maximum of intensity 350 or 400 revolutions per minute, and the direction of the current is then reversed nearly 6000 times per minute; here, however, the alternate currents are not brought into one.* In the machine made by Mr. Wilde for the Commissioners of Northern Lighthouses, the first armature is made to revolve about 2500 times a minute, generating 5000 waves of electricity. These alternate currents are converted into an intermittent current moving in one direction only by means of a commutator. The second armature revolves 1800 times a minute, generating 3600 alternately opposed waves of electric force, which are picked up and sent in one direction by a commutator, as in the former case.†

It is evident that when a good friction contact is to be kept between pieces of metal moving at these enormous velocities, the wear and tear is very great. For a long time,

* Quarterly Journal of Science, vol. i., p. 73. January, 1864.

† *Ibid.*, vol. iii., p. 504. October, 1866.

however, it was thought that these difficulties were inherent to the magneto-electric machine, until electricians found, first, that the almost instantaneous flash of the current could be considerably lengthened out, and then that the successive waves generated could be so produced as to flow in the same instead of in opposite directions.

These important desiderata are supplied in a magneto-electric machine of a novel form, invented by M. Gramme. The principle is not difficult to understand. Take a long bar of soft iron, E, E' , Fig. 1, round which is coiled an insulated copper wire; to this bar, forming an electro-magnet, let a permanent magnet, $s N$, be presented, the south pole being nearest to the iron bar. Now move the permanent magnet in the direction of the arrow parallel with itself, with a uniform velocity, and always maintaining the same distance from the bar. The south pole of the permanent magnet will produce a north magnetic pole in the portion of the iron bar nearest to it; and the gradual displacement of this pole from one end to the other of the iron bar, caused by the motion of the magnet, will induce in the surrounding wire an electric current which may be rendered evident by the galvanometer, G . This current will not be instantaneous: it will continue to flow during the whole time the magnet is moving between the two ends, $E E'$, of the iron bar, and its time of duration may therefore be varied at pleasure.

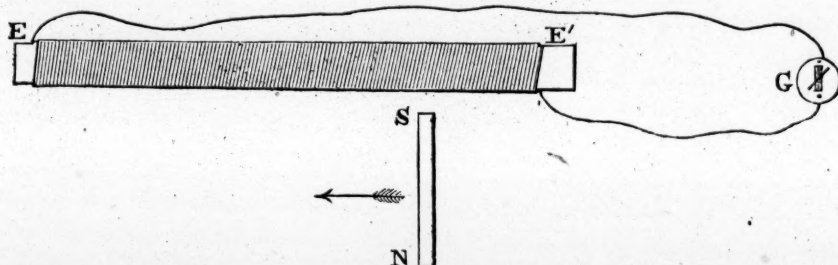
This experiment shows that it may be possible, by proper arrangements, to realise a machine which will furnish a continuous current of electricity for as long as may be desired. We have only to imagine the electro-magnet, instead of being the straight bar shown in Fig. 1, bent into a circular form as at E, E', E'', E''' , Fig. 2.

Submit this annular electro-magnet simultaneously to the influence of the two poles of the permanent horse-shoe magnet, $N S$, and at the same time imagine it to revolve on its axis in the direction shown by the arrows.

The south pole, s , of the horse-shoe magnet will produce in that portion of the ring, E , which is near it an electric current in a particular direction, as may be inferred from what we have said respecting the straight bar, Fig. 1. But the north pole, N , of the magnet will likewise produce in the part of the ring which is in its neighbourhood, E'' , an electric current flowing in the opposite direction; and it is easily conceived that in the two portions of the ring, E' and E''' , which are in what may be called the mean position, there is no current at all. If, therefore, we wish to collect

the two contrary currents produced simultaneously in the wire surrounding the electro-magnet, we have only to connect the wires at the mean position to two conductors by friction contacts, $F F'$, when the current can be carried away to a galvanometer, G , and rendered sensible.

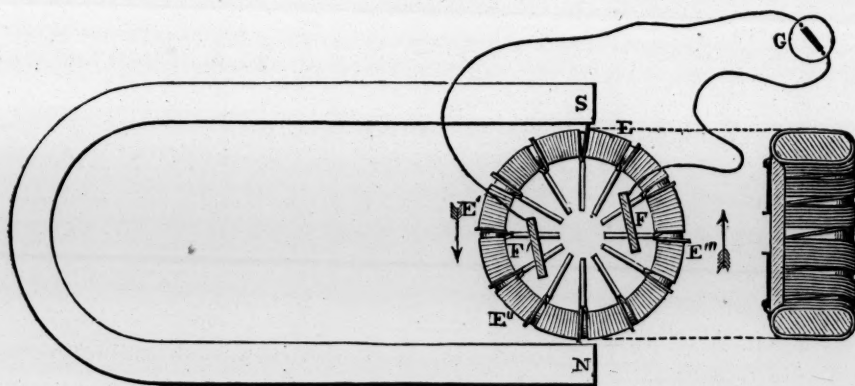
FIG. 1.



The principle of the arrangement being thus understood, the construction of the machine itself will be readily intelligible.

It consists of a permanent horse-shoe magnet, S, O, N , Fig. 3, between the poles of which revolves an electro-magnet. This electro-magnet consists of a ring of soft iron, round which is wound an insulated conducting wire, presenting no solution of continuity. It may be conceived as being an ordinary straight electro-magnet bent round in

FIG. 2.



a circle, and the two ends of the conducting wire soldered together to establish continuity.

In Figs. 4 and 7 the electro-magnet is represented at A in section, whilst in Figs. 3 and 5 it is shown at A with the covering wire on it. It revolves round its axis on an axle to which movement is communicated either by means of

belting or with toothed gearing, shown in Figs. 3 and 4, worked by a handle, M.

The current is generated and collected in the following way:—The wire surrounding the electro-magnet is, as we have said, continuous, but it is disposed in 40 sections or elements, each consisting, say, of 100 turns. The outer end of the coil of one section forms the commencement of the first coil of the next section, and so on. The whole of the wire is therefore divided into 40 equal sections, being, however, continuous throughout.

To understand better how an uninterrupted current is produced, let us imagine a line to be drawn equatorially, or perpendicular to the lines of force between the poles of the horseshoe magnet, and dividing the ring armature into two parts; suppose likewise that to the two ends of one of the 40 coils two wires are soldered, the other ends of which are attached to a galvanometer. Now let the ring be intermittently revolved in one direction, so as to give to the said coil a succession of movements of about 10 degrees, stopping each time to permit the galvanometer needle to resume its normal position. It will then be seen that the whole time the coil is above the equatorial line the galvanometer needle will be urged in the same direction, and the currents may be called *positive*. But as soon as the said coil crosses the equatorial position, the currents generated in it will be *negative*, and in the opposite direction to what they were at the other half of the circle. This experiment shows that a reversal of the direction of the movement carries with it a reversal of the direction of the current.

From this insight into what is produced in one of the sections, the general phenomena produced by the whole circle of coils are easily understood. The 20 sections which are on one side of the equatorial position are the source of positive currents; these may be of unequal intensity among themselves, but for a uniform velocity of rotation their sum is evidently constant, for as one coil crosses the equatorial line from north to south an opposite one comes up from south to north to take its place. On the other hand, the 20 sections which are on the other side of the equatorial line are the seat of negative currents, the sum of whose intensities is likewise constant, and equal to that of the positive currents.

Thus the revolving armature presents two groups of coils, generating two equal but opposite streams of electric force. The wire being unbroken the currents neutralise each other,

and there is no circulation. The result may be likened to what would be produced by taking two batteries, each of 20 cells, and connecting them in opposition by joining similar poles.

The problem now is to pick up these dormant currents and utilise their force. Its solution is apparent from the comparison we have just made. To collect the electric current from two batteries which are connected together in opposition, it is only necessary to fasten conducting wires to the two points of contact of similar poles, when the whole force of the batteries will flow along these wires. They were hitherto opposed, they now flow together, quantity-wise. M. Gramme, in the second portion of his invention, has adopted this artifice in an ingenious manner.

The various sections of the continuous electro-magnet are connected with radial pieces of copper shown at *R* in Figs. 3, 4, and 7, insulated one from the other, but coming very close. The termination of one coil of wire and the commencement of the adjacent coil are soldered to the same radial connector, of which therefore there are as many as there are coils. These radial connectors, on approaching the centre, are bent at right angles, as shown at *R*, Figs. 4 and 7, and pass through to the other side, where their ends form an inner concentric circle, being still insulated one from the other.

Two friction pieces *F* (Figs 4, 5, and 6) consisting of discs of copper, are pressed by means of springs shown at *r* (Figs. 5 and 6) against the circle formed by the extremities of the conducting radii *R*, at two points which are accurately in the equatorial line; that is to say, at the place where the equal and opposed currents generated in the upper and lower halves of the ring neutralise each other. Consequently the currents are collected and flow together along conducting wires, which are fastened to the friction pieces *F*.

The perfect continuity of the current so obtained, is secured by causing the friction pieces *F* to touch simultaneously several of the radial conductors *R*, consequently the metallic circuit is never broken.

The effects produced by these machines vary with the rapidity of rotation. Experience shows that the electromotive force is sensibly in proportion to the velocity; but it is probable that this force tends towards a limit, corresponding to a particular velocity, beyond which the electromotive force would remain constant, or even diminish. Moreover, the electromotive force is greater in proportion to the

number of coils encircling the iron ring, but the relation between these two quantities has not yet been determined. The theoretical resistance of the machine should be one-fourth of the whole resistance of the wire wound round the ring armature; but the actual resistance is not so great, since each friction-disc always touches several radii, R , and the resistance of the coils thus embraced by the friction-disc has to be subtracted from the resistance of the circuit.

The possibility of augmenting the strength of the current by increasing the dimensions of the machine is too obvious to need more than a passing allusion. The effects may also be increased by connecting together several such machines, as galvanic piles are connected, either for intensity or quantity. The quality of the current likewise differs according to the kind of wire surrounding the armature, a short thick wire producing effects of quantity, and a long thin wire, of intensity. It is also easy to see that two horse-shoe magnets, instead of one, may be made to act on one ring armature; that is to say, it may be actuated by four poles instead of two, or even by a greater number; always having a friction-disc between each pair of poles. Moreover, the permanent horse-shoe magnet may be replaced by electro-magnets, which can be excited by a portion of the current derived from the machine itself, according to the now well-known method. At the beginning of rotation the residual magnetism of these electro-magnets will induce a feeble current in the ring; one half of this passes round the electro-magnets, the four poles of which react on the armature. Of the four friction pieces, two carry half the current to excite the electro-magnets, and the machine rapidly attains the maximum effect. From conducting wires attached to the other two friction pieces a powerful current is available.

A machine of this kind, containing two horse-shoe electro-magnets, one for exciting and the other for the exterior current, and having round each pole 7 kilos. of copper wire 3 m.m. diameter, when worked by hand, decomposes water, and fuses 26 centims. of iron wire 9-10ths m.m. in diameter. However slowly the armature is rotated, the needle of a large galvanometer having the wire only once round is deflected, and the effects increase in intensity as the velocity of rotation increases, up to a maximum of 700 or 800 turns a minute, a velocity which is easily obtained when steam is employed.

Such a machine, giving an absolutely continuous current

Fig. 3.

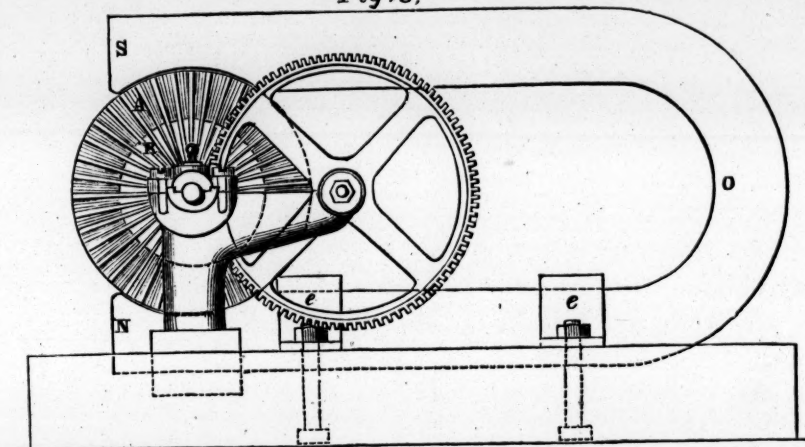


Fig. 4.

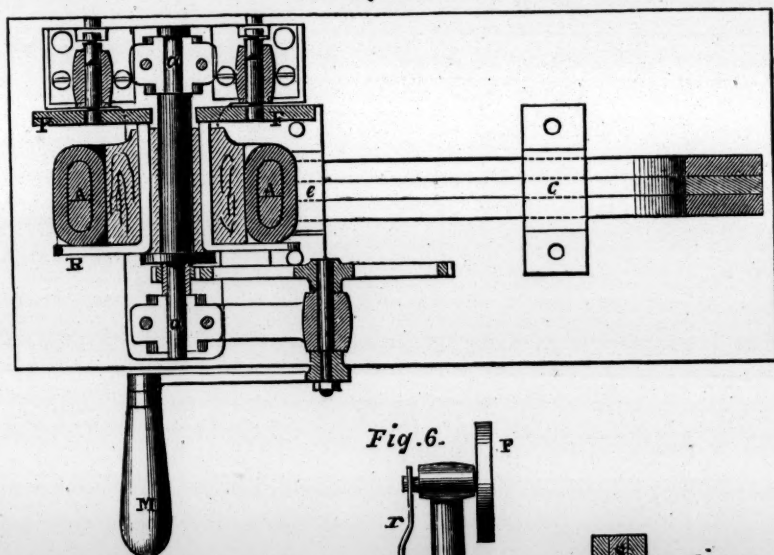


Fig. 6.

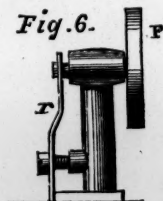


Fig. 5.

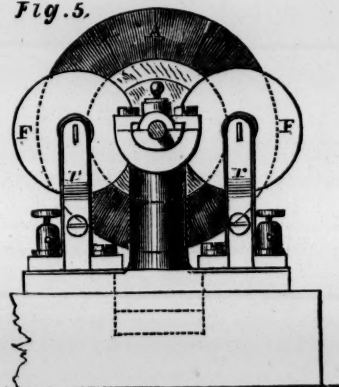
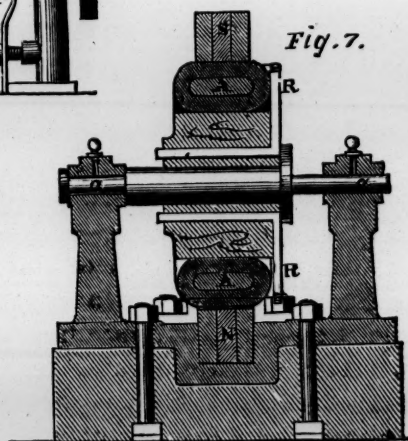


Fig. 7.



of electric force by the mere turning of a wheel, is of value outside the physical laboratory. It is available—(1) for medical purposes; (2) for telegraphy; (3) for electroplating, gilding, &c.; (4) for military purposes, signalling, explosions, &c.; (5) for chemical decompositions; and (6) for electric illumination.

A large machine, which has lately been exhibited in London, driven by a $2\frac{1}{2}$ -horse-power engine, produced a light equal to 8000 candles; a copper wire about $1\frac{1}{4}$ m.m. in thickness, suspended between the poles, became instantly red-hot with a revolution of little over 300 in a minute. Larger machines are being made that will probably give a light equal to 25,000 candles.

This machine has lately been examined by the French *Société d'Encouragement*, and in accordance with the recommendation of the reporter, Count du Moncel, a prize of 3000 francs has been awarded for it to M. Gramme; whilst the manager of the "Alliance Company," M. Joseph Van Malderen, who superintended its manufacture, has had awarded to him a gold medal. In his report, Count du Moncel says that a machine 1.25 metre in height, 0.8 metre long, and the same in width, driven by a 4-horse engine, gave a light equal to 900 carcel lamps. It also heated to redness two juxtaposed copper wires 12 metres long and 0.7 m.m. diameter, and fused an iron wire 2.5 metres long and 1.3 m.m. thick.

The constancy of direction of the electric current generated by this machine is, however, not of so great an importance for the electric light as for other purposes for which it may be used. Indeed, the electric light is by many electricians thought to be superior when produced by a magneto-electric machine of the old form without any commutator. The alternate reversal of the currents of electricity produces no flickering or irregularity in the arc of light, as they occur far too quickly to be appreciated by the eye, whilst the rapid reversal of the direction causes the carbons to wear away with great regularity, thus enabling the point of light to be kept more easily in the focus.

For the electro-deposition of metals—copper, silver, &c., constancy of direction of current is indispensable, and here the experiments show a marked superiority of the Gramme machine over other magneto-electric machines.

In the galvanoplastic works of M. Christoffe, of Paris, where experiments have been going on for more than a year, it is found that the best machine hitherto known, when moved with a velocity of 2400 revolutions per minute, only deposits

170 grammes of silver per hour; whilst a smaller Gramme machine moved with a velocity of 300 revolutions per minute deposits 200 grammes of silver per hour; the temperature of the annular armature not exceeding 50° C., with a velocity of 275 revolutions, no elevation of temperature is experienced. It will be easily comprehended how strongly this result, obtained with a speed of rotation eight times less than hitherto required, speaks in favour of M. Gramme's invention. Usually at M. Christofle's the circuits are arranged to deposit 600 grammes of silver per hour, and the manager of the factory finds that the deposition with this machine takes place with a regularity and constancy which leaves nothing to be desired, and which cannot be obtained by using any other source of electricity.

Recently, the electric light generated by a Gramme machine has been exhibited on the Victoria Tower of the Houses of Parliament. The machine is placed in the vaults of the House of Commons, near to the boilers, and is worked by a small engine, which was already there, and was convenient for the purpose. From the machine two copper wires, half an inch diameter, are led along the vaults to the base of the clock tower, and thence upwards to the signalling point, a total length of nearly 900 feet, being about three times the distance that an electric current has ever before been conducted for a similar purpose. The signalling apparatus is placed in a lantern 5 feet high, 4 feet wide, and having a semi-circular glazed front, which projects from the lantern of the belfry on the north side of the tower, or that overlooking the Victoria Embankment. It consists—first, of a fixed table, in which is inserted a flat brass ring 16 inches diameter and 1 inch broad, which serves as a roller path for the apparatus carrying the lamp and reflector; next, there is a circular revolving table, having bearings on the roller path, and which is moved around a central pivot projecting from the fixed table, being actuated by a worm wheel and screw. By means of this arrangement the light can be directed horizontally from side to side through an arc of 180° . It could, of course, be made to sweep the whole of the horizon, but the position of the lantern with regard to the clock tower is such as to enable the light to be seen through the range of a semi-circle only. Upon the revolving table, and hinged to it at the front is the elevating table, which has a screw adjustment to the rear by which the light can be raised or depressed, being capable of vertical training through an arc of 25° . On the elevator is placed the lamp

table, upon which again is a sliding platform, on which the lamps themselves stand. There are two lamps, which are in use alternately, the carbon points lasting but four hours, while the House frequently sits for ten.

The copper conductors terminate at the fixed part of the machine, and the method of carrying the current from them to the lamps is very ingenious, the moving parts of the apparatus forming in themselves conductors. The negative conductor is placed in metallic contact with one hinge of the elevator table through the centre pin on which the table revolves, and the positive conductor with the other hinge by means of the brass roller path. The currents from those points are conducted to the lamp table, and thence through the traversing platform to the lamps, metallic contact being obtained throughout the whole circuit by means of flat springs moving over flat surfaces. The changing of the lamps is effected, without any appreciable break of continuity in the light, by means of the traversing platform on which they stand, and which has a sliding motion from side to side. When the carbon points in one lamp are nearly consumed, the traverser is quickly shifted from right to left, or *vice versa*, as may be necessary. The break of contact is but momentary, and only exists during the time required to move the traverser rapidly through a space of six inches. The light will not become extinct during that period, as there is not sufficient time to allow the incandescence of the carbon to entirely subside. The springs under the lamp thrown out of use are by this action removed from the metal plate in the lamp table, and the springs under the fresh lamp are brought into contact, and the light is at once produced anew.

The intensifying apparatus at present in use is a holophole lent by Messrs. Chance, and through which the rays are sent in parallel lines. It is 21 inches in diameter, and is composed of lenses, surrounded by annular prisms, the centre part refracting the rays and the outer rings reflecting them. Should the electric light be adopted, a special lens will be constructed, by means of which the rays will be diffused through an arc of 180° , instead of being sent in one direction only. The cost of this electric light is at present estimated at 10d. per hour:

It may be of interest if we consider some matters of scientific interest in connection with this machine. In the first place, it possesses an enormous advantage over the voltaic battery in the absolute constancy of the current so long as the velocity of rotation is uniform. In an experiment carried

on for eight hours with one of the first machines constructed, the deviation of the needle of a galvanometer was absolutely invariable. Again, a voltaic battery is a complicated piece of apparatus; for each element consists of four separate solid pieces (the outer cell, the porous cell, the positive and the negative element) and two liquids, whilst in most experiments a considerable number of batteries is required. From this multiplicity of parts a voltaic battery is subject to many accidental derangements, which are likely to weaken if not destroy its power. With the magneto-electric machine there is no complication. All the parts are solidly connected together, and no special care is required.

It must also be remembered that a powerful voltaic battery costs almost as much when it is at rest as when in action. The magneto-electric machine, on the contrary, costs nothing when it is not producing an external current. This may be understood in two senses. It is, of course, evident that when no current is required the rotation of the machine may be stopped; but it is a remarkable fact that, even when rotation of the armature is still going on, no mechanical force is expended except that necessary to overcome friction, provided the exterior current does not flow. To understand this, let us examine a little more closely into the working of the machine. In the first place, suppose the machine to be in rapid movement, and furnishing a current in an exterior circuit, it will be observed that the armature does not get hot; from this it may be concluded that all the mechanical force transmitted to the machine is converted into electricity, since none is changed to heat. In the next place, the machine continuing to revolve with the same speed, suppose the exterior circuit to be broken; still the machine does not rise in temperature, showing that in this case there is neither production of heat nor electricity, and consequently no waste of mechanical force. From the way in which the currents in the armature are generated, when there is no exterior circuit along which they can flow, they neutralise one another, and keep in such perfect equilibrium that there is absolutely no circulation, and consequently no heating.

If the Gramme machine is set in motion by a force just sufficient to turn it with a definite velocity when the exterior current is flowing, and if the outer circuit is suddenly broken, the machine is seen to acquire an increasing velocity, showing that the mechanical force applied to it, being no longer capable of going off as electricity,

spends itself then in augmenting the velocity of the moving parts of the machine.

On the other hand, if the machine is kept at a certain speed of revolution whilst the outer circuit is broken, and the circuit is then suddenly closed, the speed instantly diminishes, showing that a portion of the force turning the machine changes into electricity.

These experiments show that, whether the machine be active or passive, there exists always a state of equilibrium between the expenditure of mechanical force and the production of electricity.

IV. THE MINERAL RICHES OF THE PHILIPPINES.

By W. W. Wood, Hong Kong.

SPAIN has always prided herself on being a "*nación minera*"—a mining nation—and there are few countries in which so great a variety and abundance of mineral wealth is found as in the Peninsula, where many of the mines have been worked from very remote times. Notwithstanding the mining colleges and administrations, and in spite of many modern inventions for saving time and abridging labour, much of the gear used in the Spanish mines is to this day of a very primitive description, and the produce of the ores less than that obtained by the adoption of modern machinery and improvements in smelting. This being the case in the mother country, it is not difficult to imagine that in a remote colony like the Philippines, and one in which as yet little has been done towards exploring the country from a mining point of view, the devices for the extraction, &c., of ores are of a still more simple and ineffective kind. In addition to this, a very misplaced economy, or perhaps want of means, has prevented several mining adventures, undertaken in various parts of the Archipelago, from resulting favourably for the projectors.

The interior of the great islands of Mindoro and Mindanao are but little known, but from their extent and variety of surface are probably rich in minerals; but geological surveys are extremely difficult, owing to the extent and impenetrable nature of the forests which cover the greater

part of them. Whatever reports may have been made by the Spanish mining engineers (of which corps a certain number are stationed in the Philippines), with one or two exceptions, they have not been published, and are buried, with other similar documents, in the archives, and practically inaccessible.

The mining operations of the natives are conducted in the simplest and most imperfect manner, and the natural consequence is that the product is of inferior quality, and the ore not fully reduced. It is so difficult to persuade this indolent and perversely ignorant people of the advantage of adopting any modern improvement, that in the manufacture of one of the greatest products of the country—sugar—it is only within a very few years that Indians rich enough to afford proper machinery for crushing the cane and boiling the juice have been induced to adopt the iron mills and proper boilers. In what are called the mines here (with a very few exceptions) the processes are precisely the same as they were before the arrival of Europeans in the colony. The theory of the native that what was done in the time of his grandfather is good enough for him at the present day, is too firmly rooted to be abolished. In addition to this, the greater part of the mining adventurers here are of a class which, having little or no means beyond their hands and a few of the rudest implements, prefer the half-idle and half-gambling life of a gold-seeker to the more solid results of constant and well-directed labour in other directions. Great ignorance is the constant source of disappointment. The most common minerals are mistaken for valuable ores, and time after time it has been the disagreeable duty of the writer to disabuse enthusiastic speculators who in the common iron pyrites thought they had discovered a vein of gold, or in the brilliant arsenical pyrites a deposit of platina. Nor is it easy to convince these people of their mistakes, for, being a very suspicious race, and generally unscrupulous, they fancy others are trying to circumvent them, and appropriate their so-called discoveries, as many of them would do to others if opportunity offered.

Gold, being very generally disseminated through the Archipelago, has naturally, from its value, and the comparative ease with which it is reduced from the ore, been the principal object of search in the Philippines. Silver (argentiferous galena) is rare, but there are innumerable points at which gold may be found; the greater part of the metal being that of "lavaderos," or washings of rivers and small streams. In such situations it is found in minute

scales, generally in the sand. In the province of South Camarines there is a gold-bearing quartz which, even with the imperfect appliances of the Indians, has produced good results ; but as their operations are confined to sinking pits which soon fill with water, which they are unable to get rid of, the works are on a very small scale. Some years since a Spanish Company—the Golden Anchor—projected a tunnel into their hill of quartz, with a view to drainage, but after expending some 20,000 dollars (a very inadequate sum) the project was abandoned, and the money wasted. The impatience of the shareholders induced them to give up the speculation I think prematurely. With the modern crushing machines it is not improbable that the Camarines gold-quartz would yield handsomely, especially if proper means were taken to drain the mines, in order that they might be worked at all seasons of the year. A curious crystallised variety of native gold is brought from Misamis and Cugayan, in Mindanao, but the gold from that quarter is said generally to be of an inferior quality to that found in Luzon. Small *pipitas* are also brought thence, though persons who discover mines are compelled, in case they wish to work them, to “denounce” them, as it is termed in Spanish mining phraseology, to the Inspector of Mines, who grants a privilege which is forfeited in case the works are not commenced within a specified period. I have never heard of any of large size being found.

One of the obstacles to progress is the enormous over-legislation in all departments of the state. Innumerable regulations restrict almost every kind of enterprise, and many of the laws are allowed to become a dead-letter for years, when they are suddenly revived, to the dismay of those who have proceeded in the supposition that their operation was really suspended. This is one of the causes why mines have languished in the Philippines. A permission to work can almost always be obtained, but the process is very frequently tedious, and to a mere Indian who has made a discovery, it is a somewhat formidable affair to obtain permission to profit by it before some unscrupulous person has taken advantage of it. The consequence is that all the gold produced in the Archipelago is the result of small washings in the rivers, or a pit sunk in the rock, which is soon filled by water, and then abandoned. The washing process is perfectly simple, the auriferous sand being scooped up, and washed in a peculiar kind of basket made of bamboo. The gold produced from ore is generally sent to market melted and cast in a shell, or any simple

mould. Much of this fused metal abounds in sulphur, which the natives are said to mix with it, and it thus becomes exceedingly brittle or *short*, breaking up when rolled. The Manila mint very properly refuses this sulphurous gold, which is sent to China, and purified there by a tedious process. The gold *dust* is generally free from adulteration, but since the introduction of galvanic gilding the greatest care is now necessary in purchasing.

Gold is common in many parts in the Philippines, and there is scarcely a stream in which it is not found in greater or less quantity. I have seen a gold-seeker at work in one of the numerous branches of the river which intersect the suburbs of Manila. The metal was washed out of the sand in minute spangles.

Gold is also collected by the various tribes of independent savages which still inhabit the centres of the larger islands, and occasionally curious ear-pendants are obtained from them, made to represent deer and other wild animals. No reliable statistics of the total production of gold in the Philippines can be had, as there are no means of ascertaining how much of the quantity found is used in the islands for jewelry and ornaments, while a good deal of that which comes to market is carried away by Chinese, who say nothing about it.

In order to supply the demand for the new gold coinage, it has been necessary, after exhausting an immense amount of Mexican and South American doubloons (the former gold currency here) to import large quantities of this metal from China, California, &c.

Gold has occasionally been found accumulated in certain parts of mountain streams in considerable quantities. An old friend of mine who was for some years governor of one of the southern provinces related to me the history of a rich find of this kind. Three Indians, professed gold-seekers, went into partnership for the purpose of exploring the upper part of a river in which they were in the habit of washing for gold. One, the uncle, furnished the supplies for the expedition, and his two nephews were his associates. They found in a deep hole where the stream fell from a height, a large quantity of gold dust, washed down by the river, and which from its gravity had settled in this spot. On their return a quarrel ensued as to how it was to be divided—the uncle claiming the largest share, as having provided the means. A lawsuit was the consequence, and meanwhile the treasure was deposited with the Governor, who assured me that the metal was of the finest touch. Subsequent

search about the same locality by others resulted in disappointment, no similar deposit being found.

In the gold-mining quartz which I have seen, the metal is either disseminated throughout the gangue in small specks, or is found in the form of thin sheets about the thickness of paper, and this is laboriously picked out from the crushed mineral with infinite labour, as the process of amalgamation is beyond the means of the native gold-miners. The gold found in the Philippines is generally bought up by Chinese or Mestizo dealers.

I am not aware of the existence of any silver mines in the Philippines. Some years ago a very rich deposit of argentiferous galena was discovered in the Island of Luzon. The ore was said also to contain a notable quantity of gold, but the affair was kept very secret. An assay having been made in Madrid, a company was formed there, and the principal shareholders were said to be Queen Christina and the Duke of Rianzures. The ore was shipped quietly to Spain, no attempt at reduction being made here, and after some time the enterprise was abandoned, as the vein became exhausted. There is no doubt that the ore was very rich, and as a regular miner was sent out to direct the work, it is probable that the mine was well worked out before it was closed.

Platina is said to have been discovered in the mountains of San Mateo, to the north-east of Manila, a great many years ago, but the story, which is the following, appears to be very doubtful. Some Indians showed to the curate of one of the villages of the district some grains of what was said to be a hard white metal, samples of which were reported to have been declared true platina by the Mexican Administration of Mines, to which they were sent. The padre naturally desired to visit the locality whence they came, but the natives always excused themselves, as they dreaded being forced to work the mine. After a great deal of threatening and persuasion, they at length consented to lead the padre to the spot, on condition that he permitted them to blindfold him. He was accordingly taken in a hammock to the place, and rapidly returned to his village. The next morning his guides disappeared, and never again made their appearance. No similar discovery has since been made.

The most important mining operation in the Philippines is that of Mancayan, where a very rich deposit of antimonial or grey copper has been discovered, and worked for some time by a company, few of the original shareholders of

which have now any interest in it, the usual impatience for grand results having caused most of them to sell out. A great deal of money has been spent in this undertaking, and it is now only beginning to yield a favourable return. The great objection to the mine is that it is situated at a considerable distance from the coast, from which it is separated by a very rugged mountain chain, intersected by deep gullies or *barrancos*, making transport both difficult and expensive. The works are conducted scientifically under experienced engineers, and the metal produced is of good quality. An immense number of obstacles have presented themselves in the course of the work, but which patience and skill have in a great measure overcome, but the great difficulty of the road to the coast is insurmountable, except at an expense which it would not be prudent to incur. The ingots of copper are carried down by natives on their backs, and the stores, &c., for the mine reach it by the same conveyance. The indomitable courage and perseverance of the original projector, and present head of the enterprise, have alone prevented its being abandoned long since. In a more favourable situation there is little doubt that the copper mine of Mancayan would be a most prosperous concern. The ore is generally massive, but some very beautiful crystallised specimens have been brought to Manila. Long before Europeans began to work there, the savages of the interior smelted this rich ore in their rude way to form pots and kettles, which appear to have been beaten out of masses of the pure metal. These are now becoming rare, and are considered great curiosities in Manila.

Great hopes were at one time entertained of larger profits from copper found in the Island of Masbate, but this, like so many other attempts made here, resulted in failure. The ore, which in many cases consisted of almost pure native copper in nodules and irregular masses, was found at a trifling depth, disseminated in the soil, but I believe never in sufficient quantity together to make it a paying speculation. This probably was partly caused by the want of mining experience, and a disinclination to risk expenses except for a certainty. A good deal of money has been wasted in the Philippines on mining speculations undertaken without experience, and carried on without the knowledge necessary to success. One of these days we shall very likely hear that great mineral riches have been discovered, and are worked successfully, for there can be but little doubt, from what is already known, that such

must exist; but if this does take place, our friends, the Spaniards, must change their present system of parsimony in their operations, or perhaps the result may be brought about by foreign energy, and the introduction of foreign capital. Mines in Spain are now worked profitably by foreign companies which yielded but poor results to the Spaniards themselves.

No lead mines have yet been worked in these islands with the exception of that of argentiferous galena already alluded to under the notices of silver, though extremely rich samples of ore have been sent to Manila for examination from both the Island of Cebu and the province of Camarines north. Not having visited the localities in which the specimens were found, I cannot say how far it would be worth while to work them. In the neighbourhood of Labo, in North Camarines, and not far from the point where galena has been discovered, is a deposit (said to be now nearly exhausted) of that rare mineral the *chromate of lead*, which hitherto has been brought almost exclusively from Siberia and Brazil. Soon after its discovery, a great number of most magnificently crystallised specimens were obtained from an excavation made by a Spaniard, who is said to have gone to the expense of having it filled up again, in order to be the sole possessor of these fine minerals. In this he was disappointed, however, as much more of the chromate was obtained, though not in such large or such perfect specimens. The crystallisation variety is accompanied by a much larger quantity of an earthy and massive kind. The natives have destroyed quantities of the crystals by pounding them to powder, to be used as sand for drying writing, and make use of the galena in the same way. I have had a large bottle filled with small crystals of chromate picked from the gangue and intended for the above purpose.

Iron appears to be abundant, and the ore very rich at what are called the mines of Augat, in the Province of Balacan. Some attempts have been made at work in the European style, but from various causes this enterprise has failed like so many others. The iron is now obtained from sample pits, dug by the natives, who reduce it in the most primitive of furnaces. The chief use to which the metal is applied is in castings for the ploughs of the country, which are very rude and ineffective implements. From Augat have been received some good specimens of magnetic iron (native loadstone), and some of the samples of ore are of the richest description.

In former days, iron was procured in the mountains of

San Ysidro, near Manila, and Government had an establishment there or near it, for the manufacture of cannon balls, &c., all of which have long been abandoned. It is said that many years ago a private individual (or company) projected works upon a large scale at this point, and machinery was imported from Europe. This also failed from the almost inaccessible nature of the locality, and the writer was assured by a friend that when he was a young man he had seen on the mountain road large pieces of iron castings, shafts, &c., which had been there left in despair by the owners, who found it impossible to get them to the mine over mountains and barrancos entirely destitute of anything in the shape of a road beyond a mere footpath.

The history of a deposit of metallic mercury in one of the southern provinces of the Island of Luzon is enveloped in a certain mystery. The only intelligible account which I have been able to obtain, and which reached me with a fine sample of quicksilver, is this:—At a point on the sea shore there is a high bank of clay, and below this clay a stratum of magnetic iron sand. By making cavities in this sand the pure mercury is found filtered into them, and when a pit is sunk through the clay into the sand, after a few hours a quantity of the perfectly pure metal is collected. No traces of any ore have been found, most probably from the fact that no one competent has taken the trouble to investigate the matter. It was said, I know not with what truth, that Government discouraged any further researches, fearing that the discovery and production of mercury in the Philippines might have a disadvantageous effect upon the mines of Almaden in Spain. One of the mining engineers assured me that the pure metal was found in the way described. This is certainly a very singular affair, as deposits of quicksilver, though occasionally occurring (as in the mines of Istria), are much less common than cinnabar, from which the greater part of mercury in commerce is derived. A story was reported that many years ago a vessel was wrecked on the coast, having a quantity of quicksilver on board, but this would seem a very lame explanation. I have particularly inquired whether anything resembling the soft shale in which globules of mercury are visible was found in this neighbourhood, but have not been able to ascertain more than what I have already related.

Coal is found in several localities in the Philippines, but the only mines which have been regularly worked are on the Island of Cebu—private enterprises which have cost much more than they have yielded. The great obstacle to

these undertakings, as well as to large agricultural establishments, is the difficulty almost always experienced in getting labourers. Chinese have been tried, but with very indifferent success, as the contract coolies generally become worthless, idle, and dissipated; while the natives have a strong aversion to anything like continued labour, excepting where they are proprietors. A native will work pretty hard for a week to gain enough to enable him to be idle for a fortnight. They require constant watching and urging, and never do anything thoroughly unless obliged to do so by unwearied superintendence. In addition to this there is the greatest dislike to mines and subterranean work, though well remunerated.

The quality of the coal hitherto obtained is not very good. As it contains pyrites it is very liable to spontaneous combustion, and in one of the mines the escape of inflammable gas has already caused some accidents, which have increased the prejudice of the natives against this kind of labour. The two principal mines in Cebu are situated in a range of mountains, which runs longitudinally through the middle of the island, and are about five miles from the coast. One of the principal expenses has been the formation and maintenance of roads, which suffer a good deal during the rainy season.

The Cebu coals have been found excellent in Hong Kong for the production of gas, though of inferior quality for steamer use.

Coal is by no means confined to the localities of the two above-mentioned mines, but is seen cropping out at various points of the mountain range. The distance to the coast is an inconvenience, and from the nature of the country, transport can only be made in carts drawn by the buffalo, a very slow mode of conveyance. Work has ceased in one of the Cebu coal mines, and it has been offered for sale; and the other is worked imperfectly, and on a small scale.

Perhaps as the shafts are deepened veins of better coal may be found, but a great deal of capital and machinery would be necessary, and all things considered it would be a very bold enterprise to attempt; though from the increase of steam vessels in the Archipelago within a few years past, there is no doubt that large supplies of good coal would find ready sale, that used here at present coming either from England or Australia, and costing proportionately high. Spanish capital is not likely to be employed here in mines; and until greater security is offered by Government, and

labour is more readily and constantly to be had, there is little hope that foreign speculators will be tempted to adventure such large sums as are indispensable to the successful working of mines.*

Lignite occurs also in several places, and a good deal of disappointment has been suffered by persons who fancied that in the deposits of this mineral in favourable situations they had fallen upon a true coal.

The only available building stone in Manila and its vicinity is a species of volcanic tufa, which composes large quarries, from which the whole city has been built. In breaking large masses of this stone, which when fresh quarried is very soft, fossil wood is frequently found imbedded in it, as well as branches of trees which have not become silicified, and occasionally fragments of *charcoal*.

In Cebu and some of the southern islands the coral reefs are resorted to for building materials as well as for lime. Limestone is found only in a few localities, but is much used for the latter purpose.

Some very pretty marbles are quarried in the island of Romblon, and at various other points handsome varieties are found which are now worked in Manila for church fountains, "sepulchral tablets," and ornamental purposes.

Good samples of gypsum (which are accompanied by the anhydrous variety) are found in the Province of Butangas, and large quantities of a fine kaolin are produced by washing the *débris* of certain decomposed rocks which are common in many places. The only use to which this valuable material is applied is for the preparation of a fine whitewash for interiors. A cold spring near Báy affords splendid specimens of a siliceous deposit, which invests twigs, leaves, &c., which fall into the water. At Tibi, in Albay, the thermal springs also deposit silex, and some of the specimens brought thence are very remarkable. The water of these springs is hot enough to cook an egg in a few minutes. On the lake of Báy are others which, however, do not leave any notable deposit.

In the foregoing account of the mineral productions of the Philippine group, I have avoided as much as possible any attempt at geological description of the localities, from the fact that I have visited some of them only and in too

* The jealous feeling which so long excluded foreign enterprise from Spain and her colonies, and the indifference which prevented the Spaniards themselves from profiting by the riches within their grasp, is beginning to give way at last. How disgusting it must be to them to recollect that when masters of California they thought it good for nothing but a pasture for cattle.

hurried a manner to enable me to furnish reliable particulars. As I have already remarked, geological examinations are difficult, from the deep forests which cover the interior. At the Cebu coal mines, which are situated in a valley between two ranges of hills, into the second of which the shafts are driven, I observed in the cuttings made along the shoulders of the hills several old sea-beachers, one above the other, at an elevation of some 500 feet above the level of the sea, composed chiefly of rotted masses of coral, some of them very large; and close to the coal the indurated clay filled with casts of fossil shells, most of them bivalve and very difficult to determine.

The matrix of the Mancayan copper is, I believe, a porphyritic rock, but cannot speak with certainty.

At one point in Cebu is noticed some masses of grey marble with white veins, blasted from the side of the hill in making the road to the mine, so handsome that, were the distance from the coast less, it would be profitable to quarry it for sale at Manila.

No general geological survey has ever been made by the Spaniards, and nearly, if not all the discoveries of minerals in the islands, have been made by the natives in their search for the precious metals.

Considerable quantities of impure sulphur are brought to Manila from the island of Samar, where it is dug and fused in large blocks. It is said that much more might be had were the demand for it larger.

The bottom of the crater of the volcano of Zual, in the province of Batangas, about 40 miles from the capital, would also furnish a good deal of sulphur, which is condensed from two or three *fumaroles*, almost constantly ejecting sulphurous vapour, in which the north-east monsoon condenses upon the leeward side of the crater, giving the ledges of the rocks the appearance of being covered with snow.

I am not aware that antimony, which is so abundant in the neighbouring island of Borneo, has ever been discovered in the Philippines, nor have any deposits of tin been found. Zinc, as *blende*, accompanies the galena, and in the north, near Mancayan, there are quantities of iron pyrites, which are brought to the mines by the semi-wild natives of the district to be used in the smelting operations. In Mindanao, near Surigao, I have found very fine arsenical pyrites most beautifully crystallised.

There can be little doubt that much has yet to be discovered in the way of valuable minerals in these islands,

but under the present system there is little encouragement to invest money in mining operations.

With regard to mineral springs but little is known. Streams strongly impregnated with iron derived from decomposing rocks are common, and a strong sulphur spring exists near Irlajala.

V. NOTES ON RECENT CHANGES IN BRITISH ARTILLERY MATÉRIEL.

By CAPTAIN S. P. OLIVER, Royal Artillery, F.R.G.S.

THE following notes embrace the more important results of the investigations and experiments carried on by various permanent and special committees in connection with the department of the Director-General of Ordnance in continuation of those last noticed in this journal in No. XXXIV., April, 1872.

The reader will observe the steady progress in our knowledge of explosives, an improvement in their manufacture and in the construction of our heavy ordnance and its adjuncts for obtaining increased accuracy, together with various nice mechanical contrivances for rapidity of traversing, elevating, and general working of the modern ponderous weapons.

I. The investigations of the special committee on gun-cotton and lithofraçteur first claim attention, on the score of the vast importance of the results obtained, which cannot fail to have a great effect on our future war *matériel*.

This committee was first appointed in September, 1871, for the purpose of considering and reporting upon the general question of the manufacture, storage, and use of gun-cotton and lithofraçteur, and was composed as follows:—

President—Colonel C. W. Younghusband, R.A.

Members—Colonel T. L. J. Gallwey, R.E.; Colonel T. W. Milward, C.B., R.A.; Lieut.-Col. C. B. Nugent, R.E.; Captain E. Field, R.N.; G. P. Bidder, Esq., C.E.; Dr. W. Odling, F.R.S.; and H. Bauerman, Esq.

Secretary—Captain W. H. Noble, R.A.

The following are the leading points which the Committee are required to investigate:—

1. Whether the employment of gun-cotton is attended with such uncertainty or peril as should induce the department to relinquish its manufacture, and its use for those military purposes for which it has hitherto been considered peculiarly valuable.
2. Whether its manufacture, in all its various stages, is a dangerous process, and one that should not be carried on near an inhabited neighbourhood, and whether additional precautions to those now in force seem necessary.
3. Whether the storage of gun-cotton, either wet or dry, is necessarily attended with danger in magazines, on shore, or on board of ship, under any or all conditions of temperature.
4. Whether, either in a pure or impure state, it is liable to spontaneous combustion, and, if so, whether such combustion would result in explosion or in mere ignition.
5. The nature of buildings best suited for the storage of gun-cotton.

The committee will, however, report upon any points in addition to those above enumerated which may arise in the course of their investigation, and to which they may consider it desirable to draw attention.

The question of safety, for transport and storage, of the substance called "*lithofracteur*," is also to be investigated by the committee.

The committee, after a careful review of the documents in their possession, and of the evidence of officers and others respecting the use and application of compressed gun-cotton, principally as regards its employment for military purposes, consider that its use is not only unattended by either uncertainty or peril, but that the material as an explosive agent is effective, certain, safe, portable, and easy in employment. They therefore feel that they are warranted in the expression of a strong opinion of its great value for military engineering purposes generally, and for submarine mining.

As regards *storage* no extended experience has been gained by the officers who have used it at Chatham and elsewhere, but within the limits of twelve months no change has been observed.

The evidence respecting the *stability* of a material which has been in practical use during a comparatively short period, is necessarily meagre, time forming an essential element in determining upon this important quality.

The committee find that considerable quantities have been sent during the past two or three years to hot and damp climates, and have undergone voyages to Australia and India without, so far as they can learn, any accident whatever. They have also learnt that some gun-cotton which was supplied by the Stowmarket Company in the summer of 1870, and kept in a magazine on the Thames, was subsequently sent to Calcutta, where it has been stored for some months. A report recently received from Colonel Kennard states that the gun-cotton shows no indication of any change.

The reports published in Austria furnish very satisfactory evidence respecting the stability of gun-cotton, and a consideration of them, together with the other evidence adduced, has satisfied the committee that no hesitation need be felt in continuing the employment of compressed gun-cotton through any fear of undiscovered unstable qualities.

They have examined a considerable number of specimens of gun-cotton, some of them purposely left impure, that have been stored at Woolwich for several years past (several specimens for periods as long as nine years) under varying conditions of exposure to light, heat, and change of temperature. Their present unaltered state furnishes fully confirmatory testimony that under at least all ordinary circumstances gun-cotton may be regarded as a stable material.

The experiments on stability of gun-cotton, extending over a long period, refer to the material in the form of *rope* or *skeins*, that is gun-cotton in the loose state, as distinguished from the substance compressed into blocks, or discs from pulp, on Mr. Abel's system. But as it has been satisfactorily proved to the committee that gun-cotton produced from the long staple cotton cannot be so perfectly purified as pulped gun-cotton, it follows that all the evidence in favour of the stability of gun-cotton in the loose state applies with much greater force to compressed gun-cotton, in the purification of which the pulping process has been applied.

As regards *manufacture*, the committee have made themselves acquainted with the nature of the several processes constituting Mr. Abel's system up to the stage in which gun-cotton is compressed into discs and ready for use.

In all these processes the material, from the moment of its conversion into gun-cotton and up to the drying stage, is in a wet state, and at the final stage of leaving the press contains from 15 to 20 per cent of water. It is throughout

every stage perfectly unflammable, and the committee are therefore satisfied that no danger can possibly result from its manufacture (with the exception of drying) in any locality, whether in or near a town.

The operation of drying, as followed at Stowmarket, seems to be open to some objections, but the committee apprehend that no difficulty will be experienced in a safe and simple method being devised, which may be easily applicable to any locality, and feel no hesitation in recording their opinion that there is no reason why the War Department should relinquish the manufacture of compressed gun-cotton.

Mr. Abel, chemist to the War Department, describes the results of some experiments he has made with certain modifications of gun-cotton by incorporating the pulp with an oxidising agent. The results appear to point to great improvements that may be effected in manufacture, attended with considerable increase of efficiency, and may be summarised as follows:—

1. There is no difficulty in incorporating with gun-cotton pulp, nitrate of potash, nitrate of soda, or chlorate of potash, in such proportions as will get the full amount of work out of the carbon in the cotton-wool; and in afterwards pressing the mixed substances into masses, as easily as ordinary compressed gun-cotton.

2. Discs made with any of these mixtures are hard and compact, and less liable to split than discs of pure gun-cotton.

3. They can be coated with a waterproofing composition, and can then be used for blasting in wet holes.

4. They are less ignitable by flame than pure gun-cotton discs, and when ignited burn more slowly.

5. When exploded by detonation, the products of combustion furnish little or no carbonic oxide, the presence of which renders the use of ordinary compressed gun-cotton objectionable in military mines.

6. Gun-cotton, mixed as described, may be kept wet like ordinary gun-cotton; and in the dry state the mixed material seems to resist the action of continued exposure to high temperature for a far longer period. It would, therefore, be more stable, and the objections to storing dry gun-cotton in any climate might be removed.

7. The cost, weight for weight, of the mixed gun-cotton is much less than the ordinary material; and the production can be increased without any additional plant.

Special Committee, 8/4/72, consider that the above

results are so important, and their realisation will acquire so high a value as bearing upon the employment of gun-cotton for military purposes, that they think the subject should be at once fully taken up.

Recommend that Mr. Abel be authorised to proceed with his experiments, and to prepare for trial samples of the mixed substances as above described.

The principal points which the committee think deserving of investigation are:—

1. Whether, when saltpetre is incorporated with gun-cotton pulp, the mixture can be compressed into discs which possess advantages over discs of pure gun-cotton in being *harder, less liable to flake, less inflammable, more stable, and not less efficient.*
2. The exact proportion of saltpetre which must be incorporated with gun-cotton pulp to develop the same amount of explosive force as pure gun-cotton, weight for weight.
3. An investigation into this and other properties of gun-cotton incorporated with nitrate of soda and chlorate of potash.
4. The cost of each of these modifications of gun-cotton, compared with ordinary gun-cotton; and their relative rate of production.
5. The special military uses for which each of them seems particularly suitable.

An important improvement in the manufacture of gun-cotton has been suggested by Mr. Abel, and the expectations he had formed have since been fully confirmed. The improvement consists in the addition of a proportion of ammonia to the gun-cotton at, or soon after, the commencement of the washing process; the effect of which is, not only to neutralise any free acid that may be left in the beaten-up pulp, but to act as a powerful solvent in removing the resinous and other organic matters locked up in the fibres of the cotton, the presence of which materially interferes with the stability of the finished product.

The importance of this step in manufacture may be judged of by the fact that, whereas the poaching or washing operation has hitherto required the use of *warm* water, and has had to be continued for a period of *sixty hours as a minimum*, but extending sometimes to *ten or even fourteen days* before complete removal of these substances and consequent purification is obtained, the ammoniacal washing completes the operation with cold water in about *twenty-four hours.*

This new development effected in the manufacture of
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pulped and compressed gun-cotton will result in a considerable saving of time and labour and in the employment of a less extensive plant.

On the 25th April, 1872, two Martello towers between Hastings and Winchelsea were destroyed by the Royal Engineer committee with gunpowder and gun-cotton in order to compare their effect in hasty demolitions. Both demolitions were considered perfectly successful, and showed that the proportion of four to one in the weights of gunpowder and gun-cotton to produce the same effect was practically correct. On the results of this experiment the committee arrive at the following conclusions:—

1. As gun-cotton is not materially, if at all, injured by being kept in a damp state, and as the operation of drying can be easily carried out, it is unnecessary to store it in the dry state, and the committee think it should not be stored dry in larger quantities than are required for the current wants of the service. Apparatus for drying should be established at all stations where dry gun-cotton is required for use.

2. The present service pattern-box is objectionable for packing dry gun-cotton; its strength is an element of danger, in the event of the accidental ignition of a store of gun-cotton packed in such boxes; and it is unnecessarily strong for transport.

3. In a store of any construction, the ignition of large quantities of dry gun-cotton packed in strong boxes will be followed by violent explosion; but in lightly-made boxes, or in boxes designed specially to facilitate the escape of the heated gas before it has reached the exploding point, and in magazines lightly constructed, ignition will probably not be followed by an explosion; but the Committee are of opinion that the experiments recorded do not afford a sufficient guarantee that ignition will not be followed by explosion if the quantity, however stored, be very large, or the building be exceptionally strong.

4. Taking these points into consideration, the committee think that dry gun-cotton, wherever stored, and in whatever quantity, should be treated as an explosive, and that the precautions now observed with explosives generally, as regards locality and description of building, should also apply to gun-cotton.

5. Gun-cotton in the wet state being perfectly un inflammable, no special regulations are necessary for its transport; in the case of dry gun-cotton, which under ordinary conditions is non-explosive, but readily inflammable, the

committee are of opinion that it may be safely moved under the regulations which may govern the transport of gunpowder.

6. The evidence obtained by the committee tends to show that pure gun-cotton is a stable material, but experience on this point is limited. They think it, therefore, preferable at present to follow the more prudent course of excluding it from magazines containing gunpowder; although they consider that gun-cotton may be stored, when convenient to do so, in magazines built for gunpowder.

It should, however, be understood that when circumstances absolutely require it, such as when a second safe store is not available, dry gun-cotton may be temporarily placed in a magazine with gunpowder.

7. The recommendations of the committee in their preliminary report, with respect to wet gun-cotton, require no amendment.

Since the above conclusions were arrived at by the special committee, the discovery has been made that compressed gun-cotton can be exploded *when wet* by means of detonation; this discovery has been fully confirmed by the results of some experiments lately carried out at Weston-super-Mare: and it is not improbable that moist gun-cotton will be utilised for bursting charges of shells in future.

On the 4th April some further trials were made near Eastbourne to determine the liability or otherwise of stores of wet gun-cotton to explosion from simple inflammation. Accordingly, two magazines were prepared at Pevensey, in each of which one ton of Abel's compressed gun-cotton discs was placed, containing 30 per cent of moisture. In one the gun-cotton discs were packed in 80 regulation boxes with their lids screwed down, and in the second the discs of gun-cotton were removed from their boxes and placed naked in a large wooden tank.

On the application of fire to the magazines, smoke and flame issued in considerable volumes and in successive bursts as the boxes caught fire, and after two hours and a half of intense conflagration the fire died away without any explosion, the whole of the gun-cotton having been totally consumed, and the interiors of the magazines glowed like furnaces. The result of this crucial experiment was most satisfactory.

The enormous importance of these experiments, as establishing the immunity from explosion of moist gun-cotton in compressed discs in certain quantities cannot be overrated,

and the further report of the committee, which has not yet been published, will be looked forward to with interest.

It is to be hoped that the Government will not overlook the valuable properties of dynamite for mining purposes, not only on account of the additional work done by this explosive in comparison with gun-cotton, but because the products of its combustion are less injurious to the health of the miners who use it.

On the other hand, from the following abstract of the report on the lithofracteur, this substance is found too defective to be introduced into the service at *present*.

"The committee are of opinion that the substance provided for their experiments, under the name of lithofracteur, has imperfectly fulfilled the absolutely necessary property of retaining its proportion of nitro-glycerine, under circumstances which might be met with during ordinary transport or storage.

"Nitro-glycerine readily exuded from a proportion of the cartridges of the lithofracteur subjected to trial, after a comparatively short exposure to a temperature not exceeding 100° F.; and although such a temperature may not in an English climate be sustained for any length of time, either during a railway journey or in a magazine, it must be borne in mind that the nitro-glycerine once exuded may not be re-absorbed, but that fresh exudation would probably take place on each fresh application of heat, and that this tendency to leakage might be facilitated by the shaking inseparable from railway transit.

"The capacity of lithofracteur for retaining nitro-glycerine is very seriously interfered with by its becoming wetted. The nitro-glycerine is readily expelled from a lithofracteur cartridge immersed in water. The readiness with which the lithofracteur parts with its nitro-glycerine, under the influence of water, is dependent probably on the presence of nitrate of soda as one of its constituents, a substance exceedingly soluble in water; and in the event of a box of cartridges getting wet, water would replace part of the nitro-glycerine, which would thus collect as a liquid form at the bottom of the box.

"The committee regret they cannot make a more favourable report upon a substance which may possess many valuable properties for industrial purposes, but they regard the tendency of some of the lithofracteur submitted to them to part with its nitro-glycerine, under conditions that can only be regarded as ordinary, as a defect too serious to be

ignored. They hope the manufacturers may succeed in overcoming the difficulties thus indicated, and enable this explosive, so useful for many purposes, to be admitted without restriction.

"The committee have no hesitation in recording their opinion that a safe and unobjectionable nitro-glycerine compound, possessing valuable explosive properties for many useful purposes, and fully meeting all the requirements of quarry owners, can be manufactured, transported, and stored in this country."

With regard to powder, it has been found that the very heavy charges of pebble powder, although they may not give the same pressures as the former charges of rifle large grain, still really do much more real damage to the guns, and will render the necessity of *re-venting* and indeed of *re-tubing* the guns much more frequent.

II. The last experiment with regard to the constant variations in the strength of gunpowder has led to a reconsideration of the lately-existing proof regulations (one and a quarter times highest service charge) for heavy guns. It is found necessary, in consequence of the unsatisfactory discrepancies in amount of pressure produced by a comparatively small increase in the charge, that proof charges should be larger than service ones, in order to ascertain whether the gun possesses superabundant strength to resist the effects of powder which may be more than ordinarily violent; and therefore the proof of guns should be conducted upon the same general principles as heretofore, viz., by using the service projectile and a charge somewhat in excess of the service one, but the amount of excess need not be so great as of old, that the gun may not be subjected to severe local pressures or strains which might permanently weaken or otherwise injure the structure of the gun under proof. The proof charge of the 12-inch gun of 35 tons will, therefore, now be as follows:—First round 110 lbs., and second round 115 lbs. of pebble powder; the projectile of service weight being used in each case. Experiments are now being carried out to determine the proportionate increase of proof over service charge for 8, 9, 10, 11, and 12-inch (25 tons) guns. It may here be noticed that the learned Professor Bashforth is disposed to question the very discordant results obtained by the committee as to the measurements of the variation of powder-pressure, as registered by the crusher-gauges and the chronoscopes of Schultze and Noble, on whose results little reliance is to be placed in consequence of their records being received on the surfaces

of cylinders, which are subject to more or less vibration from *toothed* wheels being used to drive them. He suggests that the law of propelling pressure could best be ascertained by means of the proposed breech-loading gun of Captain Morgan, R.A., described and figured in No. XXXII. of the "Quarterly Journal of Science," October, 1871.

III. In consequence of the accidental bursting of five cast-iron smooth-bore 68-pounders and one 24-pounder gun at Madras, the special committee have made experiments with the view of testing the action and ascertaining the general nature of Indian-made gunpowders; and the results prove these powders to possess exceptionally violent properties, due principally to the highly inflammable and readily oxidisable character of the charcoal used in manufacture, which in future is to be modified. The following analysis of the charcoals, both Indian and English, will show that the Indian charcoal is not dissimilar to that used in the Spanish Government powder, which has long been known as brutal in its action and differs greatly in composition from that used at Waltham Abbey and by the English makers. The analysis of the charcoal, as well as that separated from the powders, furnished the following results, the figures quoted being the mean of two determinations:—

	Indian Charcoal.	Charcoal from Madras powder.	Charcoal from Ishapore powder.
Carbon . . .	73·92	78·70	76·63
Hydrogen . .	3·52	3·06	3·28
Oxygen, &c. .	20·22	13·56	17·68
Ash	2·34	4·68	2·41

The following are the results of the analysis of average samples of English dogwood, willow, and alder charcoal as used at Waltham Abbey, and of Spanish charcoal:—

	Dogwood.	Willow.	Alder.	Spanish.
Carbon	83·80	84·41	87·00	76·29
Hydrogen . . .	3·28	3·24	2·98	3·31
Oxygen, &c. . .	11·21	10·71	8·78	14·87
Ash	1·71	1·64	1·24	5·53

The dogwood charcoal is decidedly more inflammable than that obtained from alder, and even more so than willow charcoal, as measured by the proportions of hydrogen and oxygen contained in each; yet, though it is the most readily oxidisable charcoal made in England, being exclusively used in the manufacture of small arm powder, it cannot be compared in this respect with any of the samples from India.

IV. Colonel Erskine's committee has finished its labours, and it is satisfactory to find that they have observed throughout their investigations a marked superiority in wheels constructed in the Royal Carriage Department in regard to quality of material and workmanship over those made elsewhere.

The committee prosecuted their inquiry under two distinct heads, viz. :—

I. WHEELS.

Experiments were made with eleven different patterns of wheels, consisting of—

- A. The service wood, with Madras nave.
- B. Messrs. Perkins and Son.
- C. Messrs. Sterne and Co.
- D. The Phantom Wheel Company.
- E. Messrs. M'Neill and Brothers.
- F. Sir W. G. Armstrong and Co.
- G. Messrs. Brown, Marshall, and Co.
- H. Superintendent of Machinery, Royal Arsenal.
- I. Colonel Clerk, R.A.
- K. Royal Carriage Department composite wheel.
- N. Messrs. Holmes and Brothers.

The only wheels which passed through the trial of travelling the prescribed distance of 1500 miles over macadamised roads, rough country, and paved roads, were those marked A., B., F., K.

After the close of the experiments the committee proceeded to ascertain the relative degrees in which these four patterns possessed the properties, enumerated below, of a thoroughly efficient wheel for transport service, viz. :—

1. Strength and endurance to withstand the strains and wear to which it is liable on service.
2. Non-liability to rapid deterioration through climatic exposure in the field.
3. Capability of being easily and quickly repaired in the field.
4. Lightness.
5. Power to resist the injurious effects of long storage.

It was found that the four patterns stood in order of merit as follows :—K., F., B., A.

The distinctive features as regards material of the wheel thus proved to be the best, being iron for the felloes, tire, and nave, and oak for the spokes.

The committee give without hesitation their opinion that iron may be advantageously used for making naves, felloes,

STATEMENT OF WHEELS SUBJECTED TO EXPERIMENTS, SHEWING RESULTS, &c.

Name of Maker, &c.	Letter of wagon and cart.	Four wheels supplied at a cost of	Description of Wheel.				Miles travelled.				Remarks.		
			Weight.	Nave.	Pipe Box.	Spokes.	Felloe.	Tire.	Wool-			Date of ceasing Total. to travel.	
									Aldershot-wich.	Over granite pavement.			
		£ cwt. qrs. lbs.											
Service wheel	A	— 2 0 3	Wrought-iron flanges.	Gun-metal.	Oak.	Ash.	Iron ring.	310	600	600	1510	—	Completed travelling test.
Perkins and Son . . .	B	80 2 1 9	Cast Steel.	Do.	Iron round*	Oak.	Trough iron.	310	600	600	1510	—	Do.
Sterne and Co. . . .	C	75 2 0 24	Wrought-iron flanges.	Do.	Steel plate.	Beech.	Do.	310	20	—	330	15 3 71	4 wheels did 190 miles . . .
Phantom Wheel Co. D	D	40 1 3 19	Cast-iron.	Do.	Steel round	—	H section iron.	301	180	—	481	24 3 71	4 wheels did 70 miles . . .
M'Neill, Brothers . .	E	40 2 2 6	Wrought-iron flanges.	Do.	12 sections of T iron with ash packing pieces.	—	Iron ring.	310	240	—	550	30 3 71	4 wheels did 490 miles . . .
Sir W. G. Armstrong and Co. Brown, Marshall, and Co.	F	56 2 3 19	Do.	Do.	Iron round*	Trough iron.	Two semi-circles.	310	600	600	1510	—	Completed travelling test.
Superintendent of Machinery.	G	80 3 0 2	Gun-metal.	Do.	Tubular iron.	Iron.	Iron ring.	310	70	—	330	18 3 71	4 wheels did 330 miles . . .
Colonel Clerk's elastic steel.	H	80 2 1 20	Do.	Do.	Iron, flat, curved.	Trough iron, with ash packing pieces.	Iron ring.	310	340	—	650	5 4 71	4 wheels did 570 miles . . .
Royal Carriage Department Madras wheel, iron felloes.	I	45 2 1 18	Wrought-iron flanges.	Do.	Steel, flat.	T iron ring with ash packing pieces.	Iron ring.	310	280	—	590	31 3 71	4 wheels did 490 miles . . .
Holmes, Brothers . .	K	— 2 0 13	Do.	Do.	Oak.*	Tubular iron D section.	Do.	310	600	600	1510	—	Completed travelling test.
	N	67 2 3 4	Do.	Do.	Iron round.	T iron in four pieces, with ash packing pieces.	Do.	600	600	1200	15 1 72	4 wheels did 944 miles. Did not compete over macadamised roads.	

* Weight of a spoke of B=8½ lbs.; of F=7½ lbs.; of K=4½ lbs.

NOTE.—All wheels 5 feet in diameter, tires 2½ inches, except F wheels which were 3 inches.

TABLE OF COMPARATIVE RANGES OF BRITISH AND FOREIGN FIELD GUNS.

Nation.	Nature of gun.	Calibre. inches.	Charge. lbs. ozs.	Nominal weight of common shell filled. lbs. ozs.	Initial velocity. feet.	Ranges, in yards.											
						1°	2°	3°	4°	5°	6°	7°	8°	9°	10°	11°	12°
BRITISH	16-pr. muzzle- loader of 12 cwt.	3'600	3 0'0	16 0'0	1355	725	1150	1560	1920	2245	2560	2840	3120	3400	3660	3920	4150
	12-pr. breech- loader of 8 cwt.	3'000	1 8'0	12 0'0	1170	580	1000	1395	1730	2045	2340	2600	2840	3065	3280	3480	3680
	9-pr. muzzle- loader of 8 cwt.	3'000	1 12'0	9 0'0	1380	660	1125	1490	1810	2095	2350	2605	2830	3040	3235	3420	3606
	6-pr. breech- loader of 8'3 cwt.	3'604	1 4'8	15 3'0	1087	410	779	1107	1410	1673	1935	2197	2446	2678	2896	3104	3304
PRUSSIAN	4-pr. breech- loader of 5'5 cwt.	3'089	1 1'6	9 6'0	1210	492	940	1290	1634	1927	2198	2460	2690	2924	3144	3362	3567
	12-pr. muzzle- loader of 12 cwt.	4'776	2 3'0	25 6'4	1006	443	820	1115	1403	1640	1845	2047	2237	2405	2570	2720	2860
FRENCH	4-pr. muzzle- loader of 6'5 cwt.	3'406	1 3'0	9 0'0	1066	415	765	1047	1305	1531	1725	1910	2080	2245	2406	2545	2685
	6-pr. breech- loader of 8'5 cwt.	3'622	1 5'6	15 0'0	—	475	875	1246	1585	1914	2215	2488	2756	2996	3215	3434	3653
BELGIAN	4-pr. breech- loader of 5'7 cwt.	3'071	1 2'7	9 3'2	1220	602	1022	1381	1723	2024	2326	2570	2822	3040	3259	3478	3675
	8-pr. muzzle- loader of 9'8 cwt.	3'830	2 0'75	14 8'0	1105	510	830	1130	1410	1675	1920	2150	2365	2565	2750	2920	3075
AUSTRIAN	4-pr. muzzle- loader of 5'2 cwt.	3'080	1 2'5	8 0'0	1054	535	835	1120	1365	1585	1795	1990	2180	2355	2520	2670	2815
	9-pr. breech- loader of 12'3 cwt.	4'200	2 11'3	24 6'0	1050	470	835	1185	1505	1810	2095	2370	2630	2880	3120	3345	3560
RUSSIAN	4-pr. breech- loader of 6'3 cwt.	3'420	1 5'6	12 10'0	1004	410	755	1075	1370	1645	1930	2170	2410	2635	2845	3045	3230
	20-pr. muzzle-loader, 3'670 cwt.	3'670	2 0'0	19 8'0	—	420	840	1260	1680	2100	2350	2600	2850	3100	3350	3565	3780
AMERICAN	Parrott, of 15'7 cwt.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	10-pr. muzzle-loader, 2'900 cwt.	2'900	1 0'0	10 0'0	—	400	800	1180	1550	2000	2250	2600	2800	3000	3200	3400	3600
	Parrott, of 8 cwt.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	3-in. muzzle-loader, 3'000 cwt.	3'000	1 0'0	11 0'0	—	645	1010	1310	1525	1835	2100	2325	2400	2790	2910	3110	3270
	ordnance of 7'3 cwt.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

and tires, but cannot be substituted for oak as a material for spokes.

2. CARRIAGE FRAMES AND BODIES.

In this instance the committee are led to the opinion that it would not be expedient to make any changes in the materials which have heretofore been used in the construction of carriage frames and bodies beyond the following ;—

1. Oak to be used universally for frames instead of ash, on account of its greater durability in store.
2. Iron angle plates to be used at the joints of all frames extending each way to a distance of from seven to twelve inches.
3. One side of all futchells and the back of splinter-bars to be faced with iron plates.

The wheel marked K, with certain modifications, is strongly recommended for adoption into the service for use with transport carriages ; but the Director of Artillery does not consider that the necessity for a new pattern wheel has been established, and consequently the service pattern remains unaltered.

The table on page 340 shows the wheels experimented upon.

V. The table on page 341, showing the velocities and ranges of the English as compared to some of the continental field guns, is satisfactory. In these days of improved small arms, it is essential that our field artillery should possess long ranging powerful weapons, and in this respect it appears we are in advance of the continental armies at present.

It has been asserted that our gunnery declined during the last few years of the old French war because the enemy seldom came out of port to face it, and alarmists have not been found wanting who see in our long-continued inactivity of peace our gunnery in danger of deterioration. It needs only a visit to Shoeburyness to convince the most sceptical that there is no fear of our artillery failing through desuetude ; but there is one danger which ought to be kept in view, and that is, our stock of powder is limited. When we have to buy Belgian powder in time of peace, where are we to obtain a sufficient quantity in actual warfare ? We need a second establishment as large as Waltham Abbey in the northern or midland counties.

VI. THE LIMITS OF OUR COAL SUPPLY.

ESTIMATING the actual consumption of coal for home use in Great Britain at 110 millions of tons per annum, a rise of eight shillings per ton to consumers is equivalent to a tax of 44 millions per annum. These are the figures taken by Sir William Armstrong in his address at Newcastle last February. As the recent abnormal rise in the value of coal has amounted to more than this, consumers have been paying at some periods above a million per week as premium on fuel, even after making fair deduction for the rise of price necessarily due to the diminishing value of gold.

Are we, the consumers of coal, to write off all this as a dead loss, or have we gained any immediate or prospective advantage that may be deducted from the bad side of the account? I suspect that we shall gain sufficient to ultimately balance the loss, and, even after that, to leave something on the profit side.

The abundance of our fuel has engendered a shameful wastefulness that is curiously blind and inconsistent. As a typical example of this inconsistency, I may mention a characteristic incident. A party of young people were sitting at supper in the house of a colliery manager. Among them was the vicar of the parish, a very jovial and genial man, but most earnest withal in his vocation. Jokes and banterings were freely flung across the table, and no one enjoyed the fun more heartily than the vicar; but presently one unwary youth threw a fragment of bread-crust at his opposite neighbour, and thus provoked retaliation. The countenance of the vicar suddenly changed, and in stern clerical tones he rebuked the wickedness of thus wasting the bounties of the Almighty. A general silence followed, and a general sense of guilt prevailed among the revellers. At the same time, and in the same room, a blazing fire, in an ill-constructed open fire-place, was glaring reproachfully at all the guests, but no one heeded the immeasurably greater and utterly irreparable waste that was there proceeding. To every unit of heat that was fully utilised in warming the room, there were eight or nine passing up the chimney to waste their energies upon the senseless clouds and boundless outer atmosphere. A large proportion of the vicar's parishioners are colliers, in whose cottages huge fires blaze most wastefully all day, and are left to burn all night to save the trouble of re-lighting. The vicar

diligently visits these cottages, and freely admonishes where he deems it necessary; yet he sees in this general waste of coal no corresponding sinfulness to that of wasting bread. Why is he so blind in one direction, while his moral vision is so microscopic in the other? Why are nearly all Englishmen and Englishwomen as inconsistent as the vicar in this respect?

There are doubtless several combining reasons for this, but I suspect that the principal one is the profound impression that we have inherited from the experience and traditions of the horrors of bread-famine. A score of proverbs express the important practical truth that we rarely appreciate any of our customary blessings until we have tasted the misery of losing them. Englishmen have tasted the consequences of approximate exhaustion of the national grain store, but have never been near to the exhaustion of the national supply of coal.

I therefore maintain most seriously that we need a severe coal famine, and if all the colliers of the United Kingdom were to combine for a simultaneous winter strike of about three or six months' duration, they might justly be regarded as unconscious patriotic martyrs, like soldiers slain upon a battle-field. The evils of such a thorough famine would be very sharp, and proportionally beneficent, but only temporary; there would not be time enough for manufacturing rivals to sink pits, and at once erect competing iron-works; but the whole world would partake of our calamity, and the attention of all mankind would be aroused to the sinfulness of wasting coal. Six months of compulsory wood and peat fuel, with total stoppage of iron supplies, would convince the people of these islands that waste of coal is even more sinful than waste of bread,—would lead us to reflect on the fact that our stock of coal is a definite and limited quantity that was placed in its present store-house long before human beings came upon the earth; that every ton of coal that is wasted is lost for ever, and cannot be replaced by any human effort, while bread is a product of human industry, and *its* waste may be replaced by additional human labour; that the sin of bread-wasting does admit of agricultural atonement, while there is no form of practical repentance that can positively and directly replace a hundred-weight of wasted coal.

Nothing short of the practical and impressive lesson of bitter want is likely to drive from our households that wretched fetish of British adoration, the open "Englishman's fireside." Reason seems powerless against the

superstition of this form of fire-worship. Tell one of the idolators that his household god is wasteful and extravagant, that five-sixths of the heat from his coal goes up the chimney, and he replies, "I don't care if it does; I can afford to pay for it. I like to *see* the fire, and have the right to waste what is my own." Tell him that healthful ventilation is impossible while the lower part of a room opens widely into a heated shaft, that forces currents of cold air through door and window leakages, which unite to form a perpetual chilblain stratum on the floor, and leaves all above the mantel-piece comparatively stagnant. Tell him that no such things as "draughts" should exist in a properly warmed and ventilated house, and that even with a thermometer at zero outside, every part of a well ordered apartment should be equally habitable, instead of merely a semi-circle about the hearth of the fire-worshipper; and he shuts his ears, locks up his understanding, because his grandfather and grandmother believed that the open-mouthed chimney was the one and only true English means of ventilation.

But suppose we were to say, "You love a cheerful blaze, can afford to pay for it, and therefore care not how much coal you waste in obtaining it. We also love a cheerful blaze, but have a great aversion to coal-smoke and tarry vapours; and we find that we can make a beautiful fire, quite inoffensive even in the middle of the room, provided we feed it with stale quartern loaves. We know that such fuel is expensive, but can afford to pay for it, and choose to do so." Would he not be shocked at the sight of the blazing loaves, if this extravagance were carried out?

This popular inconsistency of disregarding the waste of a valuable and necessary commodity, of which the supply is limited and absolutely unrenovable, while we have such proper horror of wilfully wasting another similar commodity which can be annually replaced as long as man remains in living contact with the earth, will gradually pass away when rational attention is directed to the subject. If the recent very mild suggestion of a coal-famine does something towards placing coal on a similar pedestal of popular veneration to that which is held by the "staff of life," the million a week that it has cost the coal consumer will have been profitably invested.

Many who were formerly deaf to the exhortations of fuel economists are now beginning to listen. "*Forty shillings per ton*" has acted like an incantation upon the spirit of Count Rumford. After an oblivion of more than 80 years,

his practical lessons have again sprung up among us. Some are already inquiring how he managed to roast 112 lbs. of beef at the Foundling Hospital with 22 lbs. of coal, and to use the residual heat for cooking the potatoes, and why it is that with all our boasted progress we do not now, in the latter third of the nineteenth century, repeat that which he did in the eighteenth.

The fact that the consumption of coal in London during the first four months of 1873 has, in spite of increasing population, amounted to 49,707 tons less than the corresponding period of 1872, shows that some feeble attempts have been made to economise the domestic consumption of fuel. One very useful result of the recent scarcity of coal has been the awakening of a considerable amount of general interest in the work of stock-taking, a tedious process which improvident people are too apt to shirk, but which is quite indispensable to sound business proceedings either of individuals or nations.

There are many discrepancies in the estimates that have been made of the total available quantity of British coal. The speculative nature of some of the data renders this inevitable, but all authorities appear to agree on one point, viz., that the amount of our supplies will not be determined by the actual total quantity of coal under our feet, but by the possibilities of reaching it. This is doubtless correct, but how will these possibilities be limited, and what is the extent or range of the limit? On both these points I venture to disagree with the eminent men who have so ably discussed this question. First, as regards the nature of the limit or barrier that will stop our further progress in coal-getting. This is generally stated to be the depth of the seams. The Royal Commissioners of 1870 base their tables of the quantity of available coal in the visible and concealed coal-fields upon the assumption that 4000 feet is the limit of possible working. This limit is the same that was taken by Mr. Hull ten years earlier. Mr. Hull, in the last edition of "*The Coal Fields of Great Britain*," p. 326, referring to Professor Ramsey's estimate, says, "These estimates are drawn up for depths down to 4000 feet below the surface, and even beyond this limit; but with this latter quantity it is scarcely necessary that we should concern ourselves." I shall presently show reasons for believing that the time may ultimately arrive when we *shall* concern ourselves with this deep coal, and actually get it; while, on the other hand, that remote epoch will be preceded by another period of practical approximate exhaustion

of British coal supply, which is likely to arrive long before we reach a working depth of 4000 feet.

The Royal Commissioners estimate that within the limits of 4000 feet we have hundreds of square miles of attainable coal capable of yielding, after deducting 40 per cent. for loss in getting, &c., 146,480 millions of tons; or, if we take this with Mr. Hull's deduction of one-twentieth for seams under two feet in thickness, there remains 139,000 millions of tons, which, at present rate of consumption, would last about 1200 years. But the rate of consumption is annually increasing, not merely on account of increasing population, but also from the fact that mechanical inventions are perpetually superseding hand labour, and the source of power in such cases is usually derived from coal. This consideration induced Professor Jevons, in 1865, to estimate that between 1861 and 1871 the consumption would increase from 83,500,000 tons to 118,000,000 tons. Mr. Hunt's official return for 1871 shows that this estimate was a close approximation to the truth, the actual total for 1871 having been 117,352,028 tons. At this rate of an arithmetical increase of three and a half tons per annum, 139,000 millions of tons would last but 250 years. Mr. Hull, taking the actual increase at three millions of tons per annum, extends it to 276 years. Hitherto the annual increase has followed a geometrical rather than arithmetical progress, and those who anticipate a continuance of this allow us a much shorter lease of our coal treasures. Mr. Price Williams maintains that the increase will proceed in a diminishing ratio like that of the increase of population; and upon this basis he has calculated that the annual consumption will amount to 274 millions of tons a hundred years hence, and the whole available stock of coal will last about 360 years.

The latest returns show, for 1872, an output of 123,546,758 tons, which, compared with 1871, gives a rate of increase of more than double the estimate of Mr. Hull, and indicate that prices have not yet risen sufficiently to check the geometrical rate of increase. Mr. Hull very justly points out the omission in those estimates which do not "take into account the diminishing ratio at which coal must be consumed when it becomes scarcer and more expensive;" but, on the other hand, he omits the opposite influence of increasing prices on production, which has been strikingly illustrated by the extraordinary number of new coal-mining enterprises that have been launched during the last six months. If we continue as we are now proceeding, a practical and permanent coal famine will be upon us within

the lifetime of many of the present generation. By such a famine, I do not mean an actual exhaustion of our coal seams (which will never be effected), but such a scarcity and rise of prices as shall annihilate the most voracious of our coal-consuming industries, those which depend upon abundance of cheap coal, such as the manufacture of pig-iron, &c.

The action of increasing prices has been but lightly considered hitherto, though its importance is paramount in determining the limits of our coal supply; I even venture so far as to affirm that it is not the depth of the coal seams, not the increasing temperature nor pressure as we proceed downwards, nor even thinness of seam, that will practically determine the limits of British coal-getting, but simply the price per ton at the pit's mouth.

In proof of this, I may appeal to actual practice. Mr. Hull and others have estimated the working limit of thinness at two feet, and agree in regarding thinner seams than this as unattainable. This is unquestionably correct so long as the getting is effected in the usual manner. A collier cannot lie down and hew a much thinner seam than this, if he works as colliers work at present. But the lead and copper miners succeed in working far thinner lodes, even down to the thickness of a few inches, and the gold-digger crushes the hardest component of the earth's crust to obtain barely visible grains of the precious metal. This extension of effort is entirely determined by market value. At a sufficiently high price the two feet limit of coal-getting would vanish, and the collier would work after the manner of the lead-miner.

We may safely apply the same reasoning to the limits of depth. The 4000 feet limit of the Royal Commissioners is *at present* unattainable, simply because the immediately prospective price of coal would not cover the cost of such deep sinking and working: but as prices go up, pits will go down, deeper and deeper still.

The obstacles which are assumed to determine the 4000 feet limit are increasing density due to greater pressure, and the elevation of temperature which proceeds as we go downwards. The first of these difficulties has, I suspect, been very much overstated, if not altogether misunderstood; though it is but fair to add that Mr. Hull, who most prominently dwells upon it, does so with all just and philosophic caution. He says that "it is impossible to speak with certainty of the effect of the accumulative weight of 3000 or 4000 feet of strata on mining operations. In all probability

one effect would be to increase the density of the coal itself, and of its accompanying strata, so as to increase the difficulty of excavating," and he concludes by stating that "In the face of these two obstacles—temperature and pressure, ever increasing with the depth—I have considered it utopian to include in calculations having reference to coal supply any quantity, however considerable, which lies at a greater depth than 4000 feet. Beyond that depth, I do not believe that it will be found practicable to penetrate. Nature rises up, and presents insurmountable barriers."*

On one point I differ entirely from Mr. Hull, viz., the conclusion that the increased "density of the coal itself and of its accompanying strata" will offer any serious obstacle. On the contrary, there is good reason to believe that such density is one of the essential conditions for working deep coal. Even at present depths of working, density and hardness of the accompanying strata is one of the most important conditions of easy and cheap coal-getting. With a dense roof and floor the collier works vigorously and fearlessly; and he escapes the serious cost of timbering. Those who have never been underground, and only read of colliery disasters, commonly regard the fire-damp and choke-damp as the collier's most deadly enemies, but the collier himself has quite as much dread of a rotten roof as of either of these; he knows by sad experience how much bruising, and maiming, and crushing of human limbs are due to the friability of the rock above his head. Mr. Hull quotes the case of the Dunkinfield colliery, where, at a depth of about 2500 feet, the pressure is "so resistless as to crush in circular arches of brick four feet thick," and to snap a cast-iron pillar in twain; but he does not give any account of the density of the accompanying strata at the place of these occurrences. I suspect that it was simply *a want of density* that allowed the superincumbent pressure to do such mischief. The circular arches of brick four feet thick were but poor substitutes for a roof of solid rock of 40 or 400 feet in thickness; an arch cut in such a rock would be all key-stone: and I may safely venture to affirm that if, in the deep sinkings of the future, we do encounter the increased density which Mr. Hull anticipates, this will be altogether advantageous. I fear, however, that it will not be so, that the chief difficulty of deep coal mining will arise from occasional "running in" due to deficient density, and that this difficulty will occur in about the same

* The Coal Fields of Great Britain, pp. 447 and 448.

proportion of cases as at present, but will operate more seriously at the greater depths.

A very interesting subject for investigation is hereby suggested. Do rocks of given composition and formation increase in density as they dip downwards, and if so, does this increase of density follow any law by which we may determine whether their power of resisting superincumbent pressure increases in any approach to the ratio of the increasing pressure to which they are naturally subjected? If the increasing density and power of resistance reaches or exceeds this ratio, deep mining has nothing to fear from pressure. If they fall short of it, the difficulties arising from pressure may be serious. Friability, viscosity, and power of resisting a crushing strain must be considered in reference to this question.

Mr. Hull has collected a considerable amount of data bearing upon the rate of increase of temperature with depth. His conclusions give a greater rate of increase than is generally stated by geologists; but for the present argument I will accept, without prejudice, as the lawyers say, his basis of a range of 1° F. for 60 feet. According to this, the rocks will reach 99.6° , a little above blood-heat, at 3000 feet, and 116.3° at the supposed limit of 4000 feet. It is assumed by Mr. Hull, by the Commissioners, and most other authorities, that this rock temperature of 116° will limit the possibilities of coal-mining. At the average prices of the last three years, or the prospective prices of the next three years, this temperature may be, like difficulties of the thin seams, an insurmountable barrier; but I contend that at higher prices we may work coal at this, and even far higher, rock temperatures; that it matters not how high the thermometer rises as we descend, we shall still go lower and still get coal so long as prices rise with the mercury. Given this condition, and I have no doubt that coal may be worked where the rock temperature shall reach or even exceed 212° . I do not say that we shall actually work coal at such depths; but if we do not, the reason will be, not that the thermometer is too high, but that prices are too low: in other words, value, not temperature, will determine the working limits.

Mr. Leifchild, in the last number of the "Edinburgh Review," in discussing this question, tells us that "the normal heat of our blood is 98° , and fever heat commences at 100° , and the extreme limit of fever heat may be taken at 112° . Dr. Thudicum, a physician who has specially investigated this subject, has concluded from experiments on his own body at

high temperatures, that at a heat of 140° no work whatever could be carried on, and that at a temperature of from 130° to 140° only a very small amount of labour, and that at short periods, was practicable; and further, that human labour daily and at ordinary periods, is limited by 100° of temperature, as a fixed point, and then the air must be dry, for in moist air he did not think men could endure ordinary labour at a temperature exceeding 90° ."

It may be presumptuous on my part to dispute the conclusions of a physician on such a subject, but I do so nevertheless, especially as the data required are simple practical facts such as are better obtained by furnace-working than by sick-room experience.

During the hottest days of the summer of 1868, I was engaged in making some experiments in the re-heating furnaces at Sir John Brown and Co.'s works, Sheffield, and carried a thermometer about with me which I suspended in various places where the men were working. At the place where I was chiefly engaged (a corner between two sets of furnaces), the thermometer, suspended in a position where it was not affected by direct radiations from the open furnaces, stood at 120° while the furnace doors were shut. The *radiant* heat to which the men themselves were exposed while making their greatest efforts in placing and removing the piles was far higher than this, but I cannot state it, not having placed the thermometer in the position of the men. In one of the Bessemer pits the thermometer reached 140° , and men worked there at a kind of labour demanding great muscular effort. It is true that during this same week the puddlers were compelled to leave their work; but the tremendous amount of concentrated exertion demanded of the puddler in front of a furnace, which, during the time of removing the balls, radiates a degree of heat quite sufficient to roast a sirloin of beef if placed in the position of the puddler's hands, is beyond comparison with that which would be demanded of a collier working even at a depth giving a theoretical rock temperature of 212° , and aided by the coal-cutting and other machinery that sufficiently high prices would readily command. In some of the operations of glass-making, the ordinary summer working temperature is considerably above 100° , and the radiant heat to which the workmen are subjected far exceeds 212° . This is the case during a "pot setting," and in the ordinary work of flashing crown glass.

As regards the mere endurance of a high temperature, the

well-known experiments of Blagden, Sir Joseph Banks, and others have shown that the human body can endure for short periods a temperature of 260° F., and upwards. My own experience of furnace-work, and of Turkish baths, quite satisfies me that I could do a fair day's work of six or eight hours in a temperature of 130° F., provided I were free from the encumbrances of clothing, and had access to abundance of tepid water. This in a still atmosphere, but with a moving current of dry air capable of promoting vigorous evaporation from the skin, I suspect that the temperature might be ten or fifteen degrees higher. I *enjoy* ordinary walking exercise in a well-ventilated Turkish bath at 150° , and can endure it at 180° .

In order to obtain further information on this point, I have written to Mr. Tyndall, the proprietor of the Turkish baths at Newington Butts. He is an architect, who has had considerable experience in the employment of workmen and in the construction of Turkish baths and other hot air chambers. He says: "Shampooers work in my establishment from four to five hours at a time *in a moist atmosphere* at a temperature ranging from 105° to 110° . I have myself worked twenty hours out of twenty-four in one day in a temperature over 110° . Once for one half hour I shampooed in 185° . At the enamel works, in Pimlico, belonging to Mr. Mackenzie, men work daily in a heat of over 300° . The moment a man working in a 110° heat begins to drink alcohol, his tongue gets parched, and he is obliged to continue drinking while at work, and the brain gets so excited that he cannot do half the amount. I painted my skylights, taking me about four hours, at a temperature of about 145° ; also the hottest room skylights, which took me one hour, coming out at intervals for a cooler, at a temperature of 180° . I may add in conclusion, that a man can work well in a moist temperature of 110° if he perspires freely."

The following, by a writer whose testimony may be safely accepted, is extracted from an account of ordinary passenger ships of the Red Sea, in the "Illustrated News," of November 9, 1872: "The temperature in the stoke-hole was 145° . The floor of this warm region is close to the ship's keel, so it is very far below. There are twelve boilers, six on each side, each with a blazing furnace, which has to be opened at regular intervals to put in new coals, or to be poked up with long iron rods. This is the duty of the poor wretches who are doomed to this work. It is hard to believe that human beings could be got to labour under

such conditions, yet such persons are to be found. The work of stoking or feeding the fires is usually done by Arabs, while the work of bringing the coal from the bunkers is done by sidi-wallahs or negroes. At times some of the more intelligent of these *are promoted to the stoking*. The negroes who do this kind of work come from Zanzibar. They are generally short men, with strong limbs, round bullet heads, and the very best of good nature in their dispositions. Some of them will work half an hour in such a place as the stoke-hole without a drop of perspiration on their dark skins. Others, particularly the Arabs, when it is so hot as it often is in the Red Sea have to be carried up in a fainting condition, and are restored to animation by dashing buckets of water over them as they lie on deck."

It must be remembered that the theoretical temperature of 116° at 4000 feet, the 133° at 5000 feet, or the 150° at 6000 feet, are the temperatures of the undisturbed rock; that this rock is a bad conductor of heat, whose surface may be considerably cooled by radiation and convection; and therefore we are by no means to regard the rock temperature as that of the air of the roads and workings of the deep coal pits of the future. It is true that the Royal Commissioners have collected many facts showing that the actual difference between the face of the rocks of certain pits and the air passing through them is but small; but these data are not directly applicable to the question under consideration for the three following reasons:—

First. The comparisons are made between the temperature of the air and the actual temperature of the opened and already-cooled strata, while the question to be solved is the difference between the theoretical temperature of the unopened earth depths and that of the air in roads and workings to be opened through them.

Second. The cooling effect of ventilation must (as the Commissioners themselves state) increase in a ratio which "somewhat exceeds the ratio of the difference between the temperature of the air and that of the surrounding surface with which it is in contact." Thus, the lower we proceed the more and more effectively cooling must a given amount of ventilation become.

The third, and by far the most important, reason is, that in the deep mining of the future, special means will be devised and applied to the purpose of lowering the temperature of the workings, that as the descending efforts of the collier increase with ascending value of the coal, a new problem will be offered for solution, and the method of

working coal will be altered accordingly. In the cases quoted by the Commissioners, the few degrees of cooling were effected by a system of ventilation that was devised to meet the requirements of respiration, and not for the purpose of cooling the mine.

It would be very presumptuous for any one in 1873 to say how this special cooling will actually be effected, but I will nevertheless venture to indicate one or two principles which may be applied to the solution of the problem. First of all, it must be noted that very deep mines are usually dry; and there is good reason to believe that, before reaching the Commissioners' limit of 4000 feet, dry mining would be the common, and at and below 4000 feet the universal, case. At present we usually obtain coal from water-bearing strata, and all our arrangements are governed by this very serious contingency. With water removed, the whole system of coal-mining may be revolutionised, and thus the aspect of this problem of cooling the workings would become totally changed.

Those who are acquainted with the present practice of mining are aware that when an estate is taken, and about to be worked for coal, the first question to be decided is the dip of the measures, in order that the sinking may be made "on the deep" of the whole range. The pits are not sunk at that part of the range where, at first sight, the coal appears the most accessible, but, on the contrary, at the deepest part. It is then carried on to some depth below the coal seam which is to be worked in order to form a "sumpf" or receptacle, from which the water may be wound or pumped. The necessity for this in water-bearing strata is obvious enough. If the collier began at the shallowest portion of his range, and attempted to proceed downwards, he would be "drowned out" unless he worked as a coal-diver rather than a coal-miner. By sinking in the deep he works upwards, away from the water, which all drains down to the sumpf.

The modern practice is to sink "a pair of pits," *both on the deep*, and within a short distance of each other. The object of the second is ventilation. By contrivances, which I need not here detail, the air is made to descend one of the pits, "the downcast shaft," then to traverse the roads and workings wherein ventilation is required, and return by a reverse route to the "upcast shaft," by which it ascends to the surface.

Thus it will be seen that, whenever the temperature of the roads and workings exceeds that of the outer atmosphere, the air currents have to be forced to travel through

the mine in a direction contrary to their natural course. The cooler air of the downcast shaft has to climb the inclined roads, and then after attaining its maximum temperature in the fresh workings must *descend* the roads till it reaches the upcast shaft. The cool air must rise and the warmer air descend.

What, then, would be the course of the mining engineer when all the existing difficulties presented by water-bearing strata should be removed, and their place taken by a new and totally different obstacle, viz., high temperature? Obviously to reverse the present mode of working—to sink on the upper part of the range and drive downwards. In such a system of working the ventilation of the pit will be most powerfully aided, or altogether effected, by natural atmospheric currents. An upcast once determined by artificial means, it will thereafter proceed spontaneously, as the cold air of the downcast shaft will travel by a descending road to the workings, and then after becoming heated will simply obey the superior pressure of the heavy column behind, and proceed by an upward road to the upcast shaft. As the impelling force of the air current will be the difference between the weight of the cool column of air in the downcast shaft and roads and the warm column in the upcast, the available force of natural ventilation and cooling will increase just as demanded, *i.e.*, it will increase with the depth of the workings and the heat of the rocks. A mining engineer who knows what is actually done with present arrangements, will see at once that with the above-stated advantages a gale of wind or even a hurricane might be directed through any particular roads or long-wall workings that were once opened. Let us suppose the depth to be 5000 feet, the rock temperature at starting 133° , and that of the outer air 60° , we should have a torrent of air 73° cooler than the rocks rushing furiously downwards, then past the face of the heated strata, and absorbing its heat to such an extent that the upcast shaft would pour forth a perpetual blast of hot air like a gigantic furnace chimney.

But this is not all; the heat and dryness of these deep workings of the future places at our disposal another and vastly more efficient cooling agency than even that of a hurricane of dry-air ventilation. In the first part of the sinking of the deep shafts the usual water-bearing strata would be encountered, and the ordinary means of "tubbing" or "coffering" would probably be adopted for temporary convenience during sinking. Doorways, however, would be left in the tubbing at suitable places for tapping at pleasure the wettest and

most porous of the strata. Streams of cold water could thus be poured down the sides of the shaft, which, on reaching the bottom would flow by a downhill road into the workings. The stream of air rushing by the same route and becoming heated in its course would powerfully assist the evaporation of the water. The deeper and hotter the pit, the more powerful would be these cooling agencies.

As the specific heat of water is about five times that of the coal-measure rocks, or the coal itself, every degree of heat communicated to each pound of water would abstract one degree from five pounds of rock. But in the conversion of water at 60° into vapour at say 100° , the amount of heat absorbed is equivalent to that required to raise the same weight of water about 1000° , and thus the effective cooling power on the rock would be equivalent to 5000° .

The workings once opened (I assume as a matter of course that by this time pillar-and-stall working will be entirely abandoned for long-wall or something better), there would be no difficulty in thus pouring streams of water and torrents of air through the workings during the night, or at any suitable time preparatory to the operations of the miner, who long before the era of such deep workings will be merely the director of coal cutting and loading machinery.

Given a sufficiently high price for coal at the pit's mouth to pay wages and supply the necessary fixed capital, I see no insuperable difficulty, so far as mere temperature is concerned, in working coal at double the depth of the Royal Commissioners' limit of possibility. At such a depth of 8000 feet the theoretical rock-temperature is 183° .

By the means above indicated, I have no doubt that this could be reduced to an *air* temperature below 110° ,—that at which Mr. Tyndall's shampooers ordinarily work. Of course the newly-exposed face of the coal would have its initial temperature of 183° ; but this is a trivial heat compared to the red-hot radiant surfaces to which puddlers, shinglers, glassmakers, &c., are commonly exposed. Divested of the incumbrance of clothing, with the whole surface of the skin continuously fanned by a powerful stream of air—which, during working hours need be but partly saturated with vapour—a sturdy midland or north-countryman would work merrily enough at short hours and high wages, even though the newly-exposed face of the coal reached 212° ; for we must remember that this new coal-face would only correspond to the incomparably hotter furnace-doors and fires of the steam-ship stoke holes.

The high temperature at 8000 or even 10,000 feet would present a really serious difficulty during the first opening of communication between the two pits. A spurt of brave effort would here be necessary, and if anybody doubts whether Englishmen could be found to make the effort, let him witness a "pot-setting" at a glass-house. Negro labour might be obtained if required, but my experience among English workmen leads me to believe that they will never allow negroes or any others to beat them at home in any kind of work, where the wages paid are proportionate to the effort demanded.

If I am right in the above estimates of working possibilities, our coal resources may be increased by about forty thousand millions of tons beyond the estimate of the Commissioners. To obtain such an additional quantity will certainly be worth an effort, and unless we suffer a far worse calamity than the loss of all our minerals, viz., a deterioration of British energy, the effort will assuredly be made.

I have said repeatedly that it is not physical difficulties, but market value, that will determine the limits of our coal mining. This, like all other values, is of course determined by the relation between demand and supply. Fuel being one of the absolute necessities of life, the demand for it must continue so long as the conditions of human existence remain as at present, and the outer limits of the possible value of coal will be determined by that of the next cheapest kind of fuel which is capable of superseding it.

We begin by working the best and most accessible seams, and while those remain abundant the average value of coal will be determined by the cost of producing it under these easy conditions. Directly these most accessible seams cease to supply the whole demand, the market value rises until it becomes sufficient to cover the cost of working the less accessible; and now the average value will be regulated not by the cost of working what remains of the first or easy mines, but by that of working the most difficult that must be worked in order to meet the demand. This is a simple case falling under the well-established economic law, that the natural or cost value of any commodity is determined by the cost value of the most costly portion of it. Thus, the only condition under which we can proceed to sink deeper and deeper, is a demand of sufficient energy to keep pace with the continually increasing cost of production. This condition can only be fulfilled when there is no competing source of cheaper production which is adequate to supply the demand.

The question then resolves itself to this. Is any source of supply likely to intervene that will prevent the value of coal from rising sufficiently to cover the cost of working the coal seams of 4000 feet and greater depth? Without entering upon the question of peat and wood fuel, both of which will for some uses undoubtedly come into competition with British coal as it rises in value, I believe that there are sound reasons for concluding that our London fire-places, and those of other towns situated on the sea coast and the banks of navigable rivers, will be supplied with transatlantic coal long before we reach the Commissioners' limit of 4000 feet. The highest prices of last winter, if steadily maintained, would be sufficient to bring about this important change. Temporary upward jerks of the price of coal has very little immediate effect upon supply, as the surveying, conveying, boring, sinking, and fully opening of a new coal estate is a work of some years.

The Royal Commissioners estimate that the North-American coal-fields contain an untouched coal area equal to 70 times the whole of ours. Further investigation is likely to increase rather than diminish this estimate. An important portion of this vast source of supply is well situated for shipment, and may be easily worked at little cost. Hitherto, the American coal-fields have been greatly neglected, partly on account of the temptations to agricultural occupation which is afforded by the vast area of the American continent, and partly by the barbarous barriers of American politics. Large quantities of capital which, under the social operation of the laws of natural selection, would have been devoted to the unfolding of the vast mineral resources of the United States, are still wastefully invested in the maintenance of protectively nursed and sickly imitations of English manufactures. When the political civilisation of the United States becomes sufficiently advanced to establish a national free-trade policy, this perverted capital will flow into its natural channels, and the citizens of the States will be supplied with the more highly elaborated industrial products at a cheaper rate than at present, by obtaining them in exchange for their superabundant raw material from those European countries where population is overflowing the raw material supplies. When this time arrives, and it may come with the characteristic suddenness of American changes, the question of American *versus* English coal in the English markets will reduce itself to one of horizontal *versus* vertical difficulties. If at some future period the average depth of the Newcastle

coal pits becomes 3000 feet greater than those of the pits near the coast of the Atlantic or American lakes, and if the horizontal difficulties of 3000 miles of distance are less than the vertical difficulties of 3000 feet of depth, then coals will be carried from America to Newcastle. They will reach London and the towns on the South Coast before this, that is, when the vertical difficulties at Newcastle plus those of horizontal traction from Newcastle to the south, exceed those of eastward traction across the Atlantic.

As the cost of carriage increases in a far smaller ratio than the open ocean distance, there is good reason for concluding that the day when London houses will be warmed by American coal is not very far distant. We, in England, who have outgrown the pernicious folly of "protecting native industry," will heartily welcome so desirable a consummation. It will render unnecessary any further inquiry into the existence of London "coal rings" or combinations for restricted output among colliers or their employers. If any morbid impediments to the free action of the coal trade do exist, the stimulating and purgative influence of foreign competition will rapidly restore the trade to a healthy condition.

The effect of such introduction of American coal will not be to perpetually lock up our deep coal nor even to stop our gradual progress towards it. We shall merely proceed downwards at a much slower rate, for in America, as with ourselves, the easily accessible coal will be first worked, and as that becomes exhausted, the deeper, more remote, thinner, and inferior will only remain to be worked at continually increasing cost. When both our own and foreign coal cost more than peat, or wood, or other fuel, then and therefore will coal become quite inaccessible to us, and this will probably be the case long before we are stopped by the physical obstacles of depth, density, or high temperature.

As this rise of value must of necessity be gradual, and the superseding of British by foreign coal, as well as the final disuse of coal, will gradually converge from the circumference towards the centres of supply, from places distant from coal pits to those close around them, we shall have ample warning and opportunity for preparing for the social changes that the loss of the raw material will enforce.

The above-quoted writer, in the "Edinburgh Review," expresses in strong and unqualified terms an idea that is very prevalent in England and abroad: he says that "The course of manufacturing supremacy of wealth and of power is

directed by coal. That wonderful mineral, of the possession of which Englishmen have thought so little, but wasted so much, is the modern realisation of the philosopher's stone. This chemical result of primeval vegetation has been the means by its abundance of raising this country to an unprecedented height of prosperity, and its deficiency might have the effect of lowering it to slow decline."

* * "It raises up one people and casts down another; it makes railways on land and paths on the sea. It founds cities, it rules nations, it changes the course of empires."

The fallacy of these customary attributions of social potency to mere mineral matter is amply shown by facts that are previously stated by the reviewer himself. He tells us that, "the coal fields of China extend over an area of 400,000 square miles; and a good geologist, Baron Von Richthofen, has reported that he himself has found a coal-field in the province of Hunan covering an area of 21,700 square miles, which is nearly double our British coal area of 12,000 square miles. In the province of Shansi, the Baron discovered nearly 30,000 square miles of coal with unrivalled facilities for mining. But all these vast coal fields, capable of supplying the whole world for some thousands of years to come, are lying unworked."

If "the course of manufacturing supremacy of wealth and of power" were directed by coal, then China, which possesses 33·3 times more of this directive force than Great Britain, and had had so early a start in life, should be the supreme summit of the industrial world. If this solid hydrocarbon "raises up one people and casts down another," the Chinaman should be raised thirty-three times and three-tenths higher than the Englishman; if it "makes railways on land and paths on the sea," the Chinese railways should be 33·3 times longer than ours, and the tonnage of their mercantile marine 33·3 times greater.

Every addition to our knowledge of the mineral resources of other parts of the world carries us nearer and nearer to the conclusion that the old idea of the superlative abundance of the natural mineral resources of England is a delusion. We are gradually discovering that, with the one exception of tin-stone, we have but little if any more than an average supply of useful ores and mineral fuel. It is a curious fact, and one upon which we may profitably ponder, that the poorest and the worst iron ores that have ever been commercially reduced, are those of South Staffordshire and the Cleveland district, and these are the two greatest iron-making centres of the world. There are no ores of copper,

zinc, tin, nickel, or silver in the neighbourhood of Birmingham, nor any golden sands upon the banks of the Rea, yet this town is the hardware metropolis of the world, the fatherland of gilding and plating, and is rapidly becoming supreme in the highest art of gold and silver work.

These, and a multitude of other analogous facts, abundantly refute the idea that the native minerals, the natural fertility, the navigable rivers, or the convenient seaports, determine the industrial and commercial supremacy of nations. The moral forces exerted by the individual human molecules are the true components which determine the resulting force and direction of national progress. It is the industry and skill of our workmen, the self-denial, the enterprise, and organising ability of our capitalists, that has brought our coal so precociously to the surface and re-directed for human advantage the buried energies of ancient sunbeams, while the fossil fuel of other lands has remained inert.

The foreigner who would see a sample of the source of British prosperity must not seek for it in a geological museum or among our subterranean rocks; let him rather stand on the Surrey side of London Bridge from 8 to 10 a.m. and contemplate the march of one of the battalions of our metropolitan industrial army, as it pours forth in unceasing stream from the railway stations towards the city. An analysis of the moral forces which produce the earnest faces and rapid steps of these rank and file and officers of commerce will reveal the true elements of British greatness, rather than any laboratory dissection of our coal or ironstone.

Fuel and steam-power have been urgently required by all mankind. Englishmen supplied these wants. Their urgency was primary and they were first supplied, even though the bowels of the earth had to be penetrated in order to obtain them. In the present exceptional and precocious degree of exhaustion of our coal treasures, we have the *effect* not the *cause* of British industrial success.

If in a ruder age our greater industrial energy enabled us to take the lead in supplying the ruder demands of our fellow-creatures, why should not a higher culture of those same abundant energies qualify us to maintain our position, and enable us to minister to the more refined and elaborate wants of a higher civilisation? There are other necessary occupations quite as desirable as coal-digging, furnace-feeding, and cotton-spinning.

The approaching exhaustion of our coal supplies should

therefore serve us as a warning for preparation. Britain will be forced to retire from the coal-trade, and should accordingly prepare her sons for higher branches of business,—for those in which scientific knowledge and artistic training will replace mere muscular strength and mechanical skill. We have attained our present material prosperity mainly by our excellence in the use of steam power; let us ever struggle for supremacy in the practical application of brain-power.

We have time and opportunity for this. The exhaustion of our coal supplies will go on at a continually retarding pace—we shall always be approaching the end, but shall never absolutely reach it, as every step of approximation will diminish the rate of approach; like the everlasting process of reaching a given point by continually halving our distance from it.

First of all we shall cease to export coal, then we shall throw up the most voracious of our coal-consuming industries, such as the reduction of iron ore in the blast-furnace; then copper smelting and the manufacture of malleable iron and steel from the pig, and so on progressively. If we keep in view the natural course and order of such progress, and intelligently prepare for it, the loss of our coal need not in the smallest degree retard the progress of our national prosperity.

If, however, we act upon the belief that the advancement of a nation depends upon the mere accidents of physical advantages, if we fold our arms and wait for Providence to supply us with a physical substitute for coal, we shall become Chinamen, minus the unworked coal of China.

If our educational efforts are conducted after the Chinese model; if we stultify the vigour and freshness of young brains by the weary, dull, and useless cramming of words and phrases; if we poison and pervert the growing intellect of British youth by feeding it upon the decayed carcasses of dead languages and on effete and musty literature, our progress will be proportionally Chinaward; but if we shake off that monkish inheritance which leads so many of us blindly to believe that the business of education is to produce scholars rather than men, and direct our educational efforts towards the requirements of the future rather than by the traditions of the past, we need have no fear that Great Britain will decline with the exhaustion of her coal fields.

The teaching and training in schools and colleges must be directly and designedly preparatory to those of the workshop, the warehouse, and the office; for if our progress is

to be worthy of our beginning, the moral and intellectual dignity of industry must be formally acknowledged and systematically sustained and advanced. Hitherto, we have been the first and the foremost in utilising the fossil forces which the miner has unearthed; hereafter we must in like manner avail ourselves of the living forces the philosopher has revealed. Science must become as familiar among all-classes of Englishmen as their household fuel. The youth of England must be trained to observe, generalise, and *investigate* the phenomena and forces of the world outside themselves; and also those moral forces within themselves, upon the right or wrong government of which the success or failure, the happiness or misery of their lives will depend.

With such teaching and training the future generations of England will make the best and most economical use of their coal while it lasts, and will still advance in material and moral prosperity in spite of its progressive exhaustion.

VII. ON THE INTRODUCTION OF GENERA AND SPECIES IN GEOLOGICAL TIME.*

By J. W. DAWSON, LL.D., F.R.S., F.G.S.,
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History Society of Montreal.

THERE can be no doubt that the theory of evolution, more especially that phase of it which is advocated by Darwin, has greatly extended its influence, especially among young English and American naturalists, within the few past years. We now constantly see reference made to these theories, as if they were established principles, applicable without question to the explanation of observed facts, while classifications notoriously based on these views, and in themselves untrue to nature, have gained currency in popular articles and even in text-books. In this way young people are being trained to be evolutionists without being aware of it, and will come to regard nature wholly through this medium. So strong is this tendency, more especially in England, that there is reason to fear that natural history will be prostituted to the service of a shallow philosophy, and that our old Baconian mode of viewing

* Forming portions of the President's Annual Address.

nature will be quite reversed, so that instead of studying facts in order to arrive at general principles, we shall return to the mediæval plan of setting up dogmas based on authority only, or on metaphysical considerations of the most flimsy character, and forcibly twisting nature into conformity with their requirements. Thus "advanced" views in science lend themselves to the destruction of science, and to a return to semi-barbarism.

In these circumstances, the only resource of the true naturalist is an appeal to the careful study of groups of animals and plants in their succession in geological time. I have myself endeavoured to apply this test in my recent report on the Devonian and Silurian flora of Canada, and have shown that the succession of Devonian and Carboniferous plants does not seem explicable on the theory of derivation. Still more recently, in a memoir on the Post-pliocene Deposits of Canada, now in course of publication in the "*Canadian Naturalist*," I have by a close and detailed comparison of the numerous species of shells found embedded in our clays and gravels, with those living in the Gulf of St. Lawrence and on the coasts of Labrador and Greenland, shown, that it is impossible to suppose that any changes of the nature of evolution were in progress; but, on the contrary, that all these species have remained the same, even in their varietal changes, from the Post-pliocene period until now. Thus the inference is that these species must have been introduced in some abrupt manner, and that their variations have been within narrow limits and not progressive. This is the more remarkable, since great changes of level and of climate have occurred, and many species have been obliged to change their geographical distribution, but have not been forced to vary more widely than in the Post-pliocene period itself.

Facts of this kind will attract little attention in comparison with the bold and attractive speculations of men who can launch their opinions from the vantage ground of London journals; but their gradual accumulation must some day sweep away the fabric of evolution, and restore our English science to the domain of common sense and sound induction. Fortunately, also, there are workers in this field beyond the limits of the English-speaking world. As an eminent example we may refer to Joachim Barrande, the illustrious palæontologist of Bohemia, and the greatest authority on the wonderful fauna of his own primordial rocks. In his recent memoir on those ancient and curious crustaceans, the Trilobites, published in advance of the

supplement to vol. i. of the Silurian system of Bohemia, he deals a most damaging blow at the theory of evolution, showing conclusively that no such progressive development is reconcileable with the facts presented by the primordial fauna. The Trilobites are very well adapted to such an investigation. They constitute a well marked group of animals trenchantly separated from all others. They extend through the whole enormous length of the Palæozoic period, and are represented by numerous genera and species. They ceased altogether at an early period of the earth's geological history, so that their account with nature has been closed, and we are in a condition to sum it up and strike the balance of profit and loss. Barrande, in an elaborate essay of 282 pages, brings to bear on the history of these creatures his whole vast stores of information in a manner most conclusive in its refutation of theories of progressive development.

It would be impossible here to give an adequate summary of his facts and reasoning. A mere example must suffice. In the earlier part of the memoir he takes up the modifications of the head, the thorax, and the pygidium or tail piece of the Trilobites in geological time, showing that numerous and remarkable as these modifications are, in structure, in form, and in ornamentation, no law of development can be traced in them. For example, in the number of segments or joints of the thorax, we find some Trilobites with only one to four segments, others with as many as fourteen to twenty-six, while a great many species have medium or intervening numbers. Now in the early primordial fauna the prevalent Trilobites are at the extremes, some with very few segments, as *Agnostus*, others with very many, as *Paradoxides*. The genera with the medium segments are more characteristic of the later faunas. There is thus no progression. If the evolutionist holds that the few-jointed forms are embryonic, or more like to the young of the others, then on his theory they should have precedence, but they are contemporary with forms having the greatest number of joints, and Barrande shows that these last cannot be held to be less perfect than those with the medium numbers. Further, as Barrande well shows, on the principle of survival of the fittest, the species with the medium number of joints are best fitted for the struggle of existence. But in that case the primordial Trilobites made a great mistake in passing at once from the few to the many segmented stage, or *vice versa*, and omitting the really profitable condition which lay between. In subsequent times they were thus obliged

to undergo a retrograde evolution, in order to repair the error caused by the want of foresight or precipitation of their earlier days. But, like other cases of late repentance, theirs seems not to have quite repaired the evils incurred; for it was after they had fully attained the golden mean that they failed in the struggle, and finally became extinct. "Thus the infallibility which these theories attribute to all the acts of matter organising itself is gravely compromised," and this attribute would appear not to reside in the trilobed tail any more than according to some in the triple crown.

In the same manner, the palæontologist of Bohemia passes in review all the parts of the Trilobites, the succession of their species and genera in time, the parallel between them and the Cephalopods, and the relations of all this to the primordial fauna generally. Everywhere he meets with the same result; namely, that the appearance of new forms is sudden and unaccountable, and that there is no indication of a regular progression by derivation. He closes with the following somewhat satirical comparison, of which I give a free translation:—"In the case of the planet Neptune, it appears that the theory of astronomy was wonderfully borne out by the actual facts as observed. This theory, therefore, is in harmony with the reality. On the contrary, we have seen that observation flatly contradicts all the indications of the theories of derivation with reference to the composition and first phases of the primordial fauna. In truth, the special study of each of the zoological elements of that fauna has shown that the anticipations of the theory are in complete discordance with the observed facts. These discordances are so complete and so marked that it almost seems as if they had been contrived on purpose to contradict all that these theories teach of the first appearance and primitive evolution of the forms of animal life."

This testimony is the more valuable, inasmuch as the annulose animals generally, and the Trilobites in particular, have recently been a favourite field for the speculations of our English evolutionists. The usual *argumentum ad ignorantiam* deduced from the imperfection of the geological record, will not avail against the facts cited by Barrande, unless it could be proved that we know the Trilobites only in the last stages of their decadence and that they existed as long before the Primordial as this is before the Permian. Even this supposition, extravagant as it appears, would by no means remove all the difficulties.

VIII. THE FUTURE OF THE ENGLISH LANGUAGE.*

By WILLIAM E. A. AXON, M.R.S.L., F.S.S.



UNIVERSAL language has been the dream of many minds. It has been a subject of frequent aspiration, hope, and despair. That the civilised earth should speak one common dialect is indeed a "consummation devoutly to be wished." The number of languages in existence at the present moment is unknown, but, as Professor Müller has said, they cannot be less than 900. Adelung has estimated the number of known dialects at 3664, of which 937 belong to Asia, 587 to Europe, 276 to Africa, and 1624 to America. Balbi has enumerated 860 languages, forming about 5000 dialects. Of these languages 53 belong to Europe, 153 to Asia, 115 to Africa, 422 to America, and 117 to Oceania. There can be no doubt that this estimate very greatly underrates in every particular the number of existing methods of speech.

If we contemplate the amazing variety of this Babel of sounds, the first sentiment is one of wonder at the sanguine hopefulness of those who expect to see this chaos reduced to order and symmetry. Some, dismayed perhaps by the great number of dialects, have thought it impossible that any one language should ever conquer all its opponents, and remain in undisputed possession of the field, and have therefore sought for a method by which the same symbol should represent one idea and many sounds. That such a scheme is absolutely impossible would be too much to say, for a plan of this kind is already applied in the case of numerals. The figure 1 is called by the Italian *uno*, by the Welshman *un*, by the German *ein*; but to all three it conveys the idea of unity. The Frenchman's *quatre-vingt-douze* is very unlike in sound to the English ninety-two, but the figures 92 represent them both.† The construction of an artificial philosophical language, if not beyond the bounds of possibility, is too far from the realms of the practical to need more than passing mention, and the chances

* A considerable portion of this paper was originally delivered as a Presidential Address, April 3rd, 1873, before the Manchester Eclectic Society.

† By a false analogy Wachter, who saw that ten figures were sufficient for all calculations, was led to suppose that all writing might be managed by an alphabet of ten letters, and this is what he proposed:—

of its adoption even when created would be of the very smallest.*

A few centuries ago, the *learned* were really in possession of a universal language. Learning, confined then to a comparatively small number of individuals, was all consigned to the Latin language. In the street the scholar spoke his mother-tongue, but in the study and in the lecture-room Latin alone was heard. He wooed his sweetheart in English or in German, as the case might be; but he wooed the muses in the words which had served Virgil and Cicero. Many circumstances contributed to this result. Latin was the language of the church, and the literary class was for a long period, to a very large extent, made up of the priestly caste. It was not that all priests were literate, the reverse being, unhappily, often the case; but outside the clerical professions there was no place for the activity and learning of the student. And the most ignorant members of the priesthood would have at least some knowledge of the Latin tongue. Latin was the common universal language of the *literati* of Europe up to the period of the *Renaissance*. The Reformation shattered the unity of the western church, and led to the use in various countries of vernacular liturgies and translations of the Bible. The successive development

Genus.	Figura.	Potestas.
Vocal	O	a, e, i, o, u.
Guttur	Q	k, c, ch, q, g, h.
Lingual	∠	l.
Lingual	⌢	d, t.
Lingual	∪	r.
Dental	∏	s.
Labial	3	b, q.
Labial	7	m.
Labial	H	f, ph, v, w.
Nasal	Λ	n.

Supposing a language existed containing only ten sounds, they might be amply sufficient for the expression of ideas, since it has been estimated that they would form 3,628,800 combinations.—*KOOPS on Paper*. 2nd. ed., 1801, pp. 28 and 32.

* Bishop Wilkins's "Real Character" is hardly known now, except from Professor Müller's masterly analysis of it, in his "Science of Language" (vol. ii., p. 47). It was based upon a classification of the attributes of the subjects of knowledge. An idea of Wilkins's, founded on the analogy of the scientific symbols used in the European languages, has been developed into a system of ideographs by De Mas (*Ibid.*, p. 48).

of the rich popular literature of Italy, Spain, France, and our own country still further weakened it. Yet we see that, so late as the time of the English commonwealth, it was necessary to write in Latin for a European audience. Milton, when pleading for a free press in that republic, used eloquent and earnest English words; but when he had to defend the commonwealth against its foreign assailants, he used the Latin tongue. Salmasius attacked the English nation before the literary tribunal of Europe, and both plea and reply are in the language of the courts. A little earlier we have a still more striking instance in the case of Lord Bacon, all of whose most important writings were written in Latin. Fancy Darwin or Huxley thinking it necessary to their fame, and to the propagation of their theories, to write in any language but their own. When Newton's grand discoveries were made, they were recorded, not in English, but in Latin. Yet, when Bacon disdained to issue in English his views on the method of philosophy, it had received the plays of Shakespeare and the authorised version of the Scriptures, and in Newton's time it had been ennobled and dignified by the mighty music of Milton's verse.

Latin retained its hold upon the physical sciences long after it had ceased to be used to any great extent in any other field of literature. Even in this field it has now lost its position. There are very few works of any great scientific importance which have been issued in Latin during the past century. At present, of the writers on science, each one uses his own language, and leaves the propagation of his views to the mercy of translators, or the linguistic acquirements of his fellow-scholars. At no date were these probably greater than at present. The knowledge of languages has become a very common accomplishment; but, after all, the acquirement of foreign idioms is a difficult thing, and there must always be in every language a sort of holy of holies, into which the feet of the Gentile can never enter.* It is also obvious that the study necessary to

* A recent writer gives his own linguistic experiences:—"As a boy, we were taught Greek and Latin, such an amount as enabled us to read a Greek testament with the use occasionally of a lexicon, and to read freely Ovid and Virgil. But our future career was selected to be one in which Greek and Latin were not subjects for examination, but French and German 'paid well;' consequently, four years were devoted to the study of these two languages,—at the end of which time we found ourselves in South Africa, where the only languages of any practical use were Dutch and Caffre. To Dutch and Caffre, consequently, we turned our attention; and, after rather more than a year's study, we were able to converse imperfectly in both these. But again were we on the point of finding these later labours useless, for there was every prospect

master merely the most important of the living languages must detract considerably from the amount of time which can be applied to the enlarging of the bounds of science. Let us disabuse ourselves of the vulgar notion that the man of science is a sort of lucky guesser, who arrives at conclusions by process of conjuring. Let us remember that he must be first of all an instructed man, well acquainted with what has already been done, and what is actually being done. De Morgan speaks very emphatically on this point: "New knowledge, when to any purpose, must come by contemplation of old knowledge, in every matter which concerns thought; mechanical contrivance sometimes, not very often, escapes this rule. All the men who are now called discoverers, in every matter ruled by thought, have been men versed in the minds of their predecessors, and learned in what had been done before them. I may cite, among those who have wrought strongly upon opinion or practice in science, Aristotle, Plato, Ptolemy, Euclid, Archimedes, Roger Bacon, Copernicus, Francis Bacon, Ramus, Tycho Brahé, Galileo, Napier, Descartes, Leibnitz, Newton, Locke. I have taken none but names known out of their fields of work, and all were learned as well as sagacious."*

But at no previous period was there such a general diffusion of scientific investigation. The problems which engage the attention of the physicists of London and Berlin are also being eagerly scrutinised by those of Florence, Boston, Melbourne, and Cracow. That men should at the same time be accomplished linguists and profound scientists, is more than can be reasonably expected. There can, then, be

of our services being transferred to India; and we heard, from good authority, that we were not likely to get on there unless we could speak Hindustani, and perhaps understood Sanscrit or Persian. Here, then, were Greek, Latin, French, German, Dutch, Caffre, Hindustani, Persian, Sanscrit, all to be learned, in order that one's own thoughts and wishes should be made intelligible to another person. In our judgment, this is not only a mistake, but it is a mistake which is remediable, and which is a slur upon the common-sense and civilisation of the world." After pointing out that in music there is but one language, he suggests that "a committee of the scientific men of all nations should be formed, which should decide on a language that shall be termed the universal language. Let us suppose that German be found to be the most expressive and complete of existing languages, and the one decided upon as the universal tongue. We commence our education, not with a superficial knowledge of several languages, but with a thorough knowledge of German only. All other nations adopt the same course; and we know that wherever civilisation has spread, wherever missionaries have resided and taught, we who speak this universal language shall be at once intelligible, and able to communicate our thoughts readily."—*Chambers's Journal*, January, 1872.

* Budget of Paradoxes, 1872, p. 4.

no doubt that this diversity of languages is an evil for science, since it puts serious difficulties in the way of the highest scientific culture, which consists, to use Dr. Matthew Arnold's phrase, in "acquainting ourselves with the best that has been known and said in the world" on the particular object of our study.

The advantage to commerce of a common language is so obvious that it needs only to be named in order to be appreciated. Is there any modern language which has any chance of becoming the general medium of civilised intercourse, both in speech and in writing? At one time the French language appeared likely to succeed to the heritage of the Latin. It was the language of diplomacy and of society; its affinity to Latin made it easy of acquisition to the Teutonic races who had learned Latin in their schools; and to the people of South Europe it was already three parts known from its analogies with their own vernaculars.* That day has passed. If any language ever becomes dominant, it is very unlikely that it will be French. France is no coloniser. She is great, but her boundaries are limited. Her home population decreases; her emigrants, instead of founding new Frances, are absorbed in the new Englands which are dotted over the globe.

The German is no more a national coloniser than the Frenchman. He increases much faster, but beyond the boundaries of the Fatherland the language makes small progress. The race goes to strengthen the American stock, but the language has no root in the American soil.

The best way to estimate the relative chances of various languages will be to ascertain the number of individuals who speak each of them. The statistics of language have not received a very large amount of attention, but the number of wide-extended languages is not very great. In this case we may safely leave out of consideration the languages which are not of European origin. The oriental tongues are not aggressive nor numerically strong enough to be factors in the problem. The materials for a rigidly accurate census of languages do not exist, but an approximately correct solution can be formed:—

PORTUGUESE.

In Portugal	3,980,000
„ Brazil	10,000,000
	13,980,000

* There was a time when the Academy of Berlin published its transactions in French.

ITALIAN.

In Italy	26,796,253
„ France	540,985
„ Switzerland	186,000
	27,524,238

Italy has a certain commercial currency in the Mediterranean, but has not taken root.

FRENCH.

In France	36,225,000
„ Belgium.	2,325,000
„ Switzerland	638,000
France has very few colonies. If all their populations spoke French, it would only add 3,631,000 persons. A million is a fair estimate	
	1,000,000
	40,188,000

RUSSIAN.

It has been said that there are 24 languages spoken in the Russian Empire, but the prevailing one is the Russ, and the number of those who speak it is reckoned at 51,370,000.

SPANISH.

Spain, including the Canary and Balearic Isles.	16,301,000
South America. If we give Spanish all the South American States except Brazil,	
there will be	27,408,082
	43,709,082

GERMAN.

German Empire	41,058,000
Austria	9,160,000
Belgium	2,747,000
Russia	985,000
Finland	1,000
Switzerland	1,838,000
	55,789,000

De Candolle has estimated the German-speaking peoples at 62,000,000, which appears too high a figure.*

* These figures are chiefly taken from the "Almanach de Gotha" for 1873, the conjectural estimates of the number of foreign-speaking people in each country being omitted. There *may be* fifty thousand Germans in Great Britain, and one thousand of them in Greece, but it is a matter of conjecture which does not affect the question we have in view.

ENGLISH.

English is spoken by 40,000,000 in the United States, by 50,000 in the republic of Liberia, by 31,000,000 British subjects in Europe, by 5,000,000 in America, by 2,000,000 in Australia, and by at least 1,000,000 more scattered over the various British dependencies in Asia and Africa, giving a grand total of 79,050,000.

From this it will be evident that English is at present the most widely spread of the languages of civilisation. But there is another point of importance which has been well put by M. de Candolle. Nations vary greatly as to the relative quickness with which they double themselves. He has worked out the problem, and has calculated the number of persons who will speak these languages in a century from now. Let us apply his method to figures of population, which sometimes vary from the estimates he has made, and see what will be the probable number of persons speaking the most important of the European languages at the end of the twentieth century.*

In England the population doubles itself in every 56 years; in the New World the Anglo-Saxons double in every 25 years. The Dutch double in 106 years; the Turks in 555 years; the Italians in 135 years; the Swedes in 92 years; the Russians in 100 years; the Spaniards in 112 years; their South-American descendants in $27\frac{1}{2}$ years. This last was Humboldt's computation, and has been adopted here, although it may be doubted if this rate of increase has not been considerably checked by the chronic anarchy to which they are subject.† The North German people double in from 50 to 60 years, and the South Germans in 167 years, say 100 years as a mean for the entire race. The French populations take about 140 years in which to double.‡

* M. de Candolle's work (*"Histoire des Sciences et des Savants depuis deux Siècles, suivie d'autres Etudes,"* par ALPHONSE DE CANDOLLE, Genève, 1873), is one of great interest, alike from the subject-matters with which it deals and from the charm of style and treatment. In the essay with which we are more immediately concerned (*"Avantage pour les Sciences d'une Langue Dominante et laquelle des Langues Modernes sera nécessairement Dominante au XXme Siècle"*), he estimates that in 1970 there will be 860 million English-speaking persons to 124 million German, and 69½ million French-speaking persons.

† These estimates are derived from the following sources:—"Universal Language," by WILLIAM WHITE, p. 3; Bath, 1850. DE CANDOLLE: *Hist. des Sciences*. *Encyclopædia Brit.*, art. "Population." *Statistical Journal*, vol. xxxiii.

‡ The following appears in the "*Lancet*," of May 3rd, 1873:—"M. Lagneau has placed before the Academy of Medicine of Paris a paper, from which it appears that the discouraging features presented by the quinquennial census

We may estimate on this basis that in the year 2000 the most important languages will be spoken by the number of persons as under :—

ITALIAN	53,370,000
FRENCH	72,571,000
RUSSIAN	130,479,800
GERMAN	157,480,000
SPANISH—	
Europe	36,938,338
S. America	468,347,904
	505,286,242
ENGLISH—	
Europe	178,846,153
United States and non- European British de- pendencies	1,658,440,000
	1,837,286,153

From this it is tolerably clear that English is the language of the future. No other European tongue can compete with it, for no other race has the same wide field for extension. The emigrants who crowd to the West, be they Latin, Teutonic, or Scandinavian, become most surely and certainly Americanised. For a time they may endeavour to retain the language of their fatherland, but the attempt is hopeless. "In America," says Sir Charles Dilke, "the peoples of the world are being fused together, but they are run into an English mould; Alfred's laws and Chaucer's tongue are theirs, whether they would or no." In South

which preceded the year 1866 are worse in the census of 1872. For the six years preceding 1872, the population has again decreased by 366,935 inhabitants—i.e., 16 individuals upon every 10,000 (the 1,597,238 inhabitants lost with Alsace and Lorraine being deducted). In order to see the extent of the decrease, it should be remembered that the former census gave an annual increase of 38 per 10,000, so that the actual decrease is 54 per 10,000. M. Lagneau shows that this thinning of the population is owing to the comparative small number of births, military service and the anxiety of parents to prevent a great division of property being at the root of the evil. The author points out that, if this system continues, France in half a century could raise an army only one-fourth superior in number to the present, as the population would have increased only one-fourth; whilst in the same half-century, the number of inhabitants having doubled in England, Russia, and Germany, these countries could raise armies double the number of the present. He hopes, however, that a change will come over France, and that sufficient work and occupation will be found for the more numerous children of each family. He cites where the mortality is the same as in France, viz., 228 per 10,000, but where the births are 354, being one-third higher than in France; the annual increase, 126 per 10,000, three times higher than French increase, and where the population is doubled in 55 years, which doubling would in France take 183 years to effect."

America Spanish is the common language, and in Brazil 10,000,000 persons use the Portuguese; but neither of these have any propagandist power, and they will not improbably disappear before the more energetic English speech. The German-speaking peoples have no colonies or dependencies; those of France are unimportant; whilst those of Great Britain are scattered over every part of the globe. The British Empire covers nearly a third of the earth's surface, and British subjects are nearly a fourth of the population of the world. The native races of India, numbering 190,000,000 human beings, are governed by a mere handful of Englishmen; and it would be no new thing in the world's history if these subject races were to learn and adopt the language of their conquerors. That our language and literature are extensively cultivated by the educated natives already we know; but how long it may take before scholastic agencies reach the great mass of the people it is hard to say.

The widespread territorial influence of the British Empire must inevitably aid in extending the boundaries of the language, and another element of equal importance is the extent of our commercial intercourse with other nations, owing to the restless energy of our people, who are to be found wherever dash and endurance are needed. The adoption of the English language by the immense population of Japan has been seriously considered by the governors of that nation.

Such, then, is the position of the English language at the present day. It is spoken by a larger number of persons than any other civilised language, and those who speak it have proved themselves to be the most energetic, enterprising, and successful of modern races. The English race has fuller opportunities for further extension and development than any other. It is therefore of importance to ascertain if this language which has these external advantages possesses also the internal qualities necessary for the common language of civilisation. The civilisation and science of to-day are due mainly to the Latin and Teutonic races. The Slavonic nations may have a great part to play in the future, but so far, their influence upon the literature and learning of the world has not been great. That language which is to be dominant must, as De Candolle has already said, have sufficient of Latin and German forms and words to show a genuine affinity with both those families of speech. Beyond this, it should be clear, simple, and brief.

A glance at the history of our language will show how

well it answers the first condition. To the strength of the Teutonic dialects it adds the clearness of the Latin, and a brevity that is all its own. A mixed language, it has combined the best elements of each. It is the language of men of business, to whom time is of importance, and who cannot afford to waste the stuff of which life is made, by roundabout phrases and ambiguous sentences. The object of those who have formed the English language might have been to see in how few words an idea could be conveyed. There is a directness of purpose about our most ordinary forms of expression. The question asked is not how can this thought be clothed in the most beautiful and appropriate diction, but how can it be rapidly and unmistakably expressed? It goes to the root of the matter, allows of no beating about the bush, but is exact, curt, pointed, and straightforward. English is not so long-winded as either French or German. De Candolle tells us that, in families where they have an equal acquaintance with French and with German, the former is always more used; and where English and French are spoken, the preference is given to English. German families, he says, settling in English or French countries quickly cease to use their own language, whilst Frenchmen and Englishmen settling in German countries are on the contrary very tenacious of their mother-tongue. It is possible to give another interpretation to these facts; but it seems not unnatural that those having choice of two roads should select the shortest and directest of them.

The English tongue has been the subject of many eulogies. Those which come from foreigners may at least claim sincerity and freedom from that national vanity which might induce an Englishman to over-estimate its beauty and importance. Jacob Grimm has said that "the English language possesses a power of expression such as was never, perhaps, attained by any human tongue. Its altogether intellectual and singularly happy foundation, and government, and development, has arisen from a surprising alliance between the two noblest languages of antiquity—the German and the Romanesque—the relations of which to each other is well known to be such that the former supplies the material foundation, and the latter the abstract notions. Yes; truly the English language may with good reason call itself a universal language, and seems chosen, like the English people, to rule in future times in a still greater degree in all corners of the earth. In richness, sound reason, and flexibility, no modern tongue can be

compared with it,—not even the German, which must shake off many a weakness before it can enter the lists with the English.”*

The great defect of our language is its absurd orthography. This is the stumbling-block which prevents the ready acquisition of the spoken language by foreigners, and hinders the majority of our own people from acquiring an intelligent acquaintance with the riches of our literature. M. de Candolle was surprised to see that intelligent English children learned to read with great difficulty. He found the reason to be that each letter has many sounds, or that each sound is written in many different ways. “They are obliged to learn word by word. It is a matter of memory, almost entirely destitute of rule.” The great defect of our language in the eyes of this critic, who is certainly not an adverse one, “is an orthography entirely irregular, so absurd that it requires more than a year for children to learn to read in it.” More than a year! The hindrance which it causes to elementary education is much greater than this.

Mr. Russell Martineau, in a report to the Philological Society, says:—“How spelling can be taught at all in elementary schools is a constant wonder to me. There is not a single rule which a teacher can lay down which has not almost as many exceptions as examples. Thus—‘Final *e* lengthens the preceding vowel, as in make, bite;’ but then, what of love, glove, tongue? ‘*G* before *e* or *i* is sounded like *j*, as in gentle, gin;’ but gig, gild, get protest. ‘*Gh* after *au* and *ou* is sounded like *f*, as laugh, cough, rough;’ but what of haughty, plough, bough? And, worst of all, what can the teacher make of the double vowels *ea* in each, bread, great; *ai* in hail, against; *au* in fault, haunch, laugh; *ou* in sound, wound, soul; *ow* in blow, trowel; *ew* in yew, shew; *ei* in receive, reign; *ie* in field, tie, friend? Or, approaching the subject from the other side, the following vowel sounds have a plurality of modes of expression, between which the luckless pupil has to choose:—

<i>a</i> in ale	<i>a</i> , <i>ai</i> , <i>ay</i> , <i>ea</i> .
<i>e</i> „ eel	<i>e</i> , <i>ee</i> , <i>ea</i> , <i>ei</i> , <i>ie</i> .
<i>e</i> „ ell	<i>e</i> , <i>ea</i> , <i>ai</i> .
<i>i</i> „ idle	<i>i</i> , <i>ie</i> , <i>ei</i> .
<i>o</i> „ old	<i>o</i> , <i>oe</i> , <i>ou</i> , <i>ow</i> , <i>ew</i> , <i>oa</i> .
<i>u</i> „ cue	<i>u</i> , <i>ue</i> , <i>ew</i> .
<i>ou</i> „ pound	<i>ou</i> , <i>ow</i> .
<i>au</i> „ fault	<i>a</i> , <i>au</i> , <i>aw</i> .

* Quoted by Mr. Pitman, in his “Manual of Phonography,” 1873, page 4.

"I am not speaking too strongly in saying that our want of systematic orthography has reduced the advantage of alphabetic writing to a minimum, and makes correct spelling virtually impossible."

"It is the universal testimony of teachers," remarks Mr. E. Jones, B.A., Head Master of the Hibernian Schools, Liverpool, "that the irregularity of our spelling is a serious obstruction to education. *The bulk of the children pass through the government schools without having acquired the ability to read with ease and intelligence, or to spell with accuracy*, although these subjects, with arithmetic, occupy most of the time in these schools. It takes from six to seven years to learn the arts of reading and spelling with a fair degree of intelligence, and to many minds the difficulties of orthography are insurmountable. The report of the Birmingham Education Aid Society shows that, after a careful examination of a large number of youths of both sexes, between the ages of thirteen and twenty, employed in the factories in that town, only four and a half per cent were able to read a simple sentence from an ordinary school book with intelligence and accuracy. What hopes can be entertained of the improvement of the remaining ninety-five and a half per cent? Education is regarded by statesmen and philanthropists as the lever by which the people are to be elevated, but *education, up to the point of reading and writing to any useful purpose, under present circumstances, is not attained by the great bulk of the population.*" Mr. J. S. Mill remarks: "It is truly a frightful consideration that the annual number of pupils who pass the highest grade in the schools aided by Government, namely, who leave the schools able to read a newspaper with understanding, is less than the number of teachers, including pupil teachers, employed in the schools! There is no doubt that a simplification of English orthography would facilitate considerably the task of learning to read."

If we advance to a higher social grade, the same evil influence manifests itself. Out of 1972 failures in the Civil Service examinations, 1866 candidates were in spelling; that is, eighteen out of every nineteen who failed failed in spelling. Dr. Morell, who states this fact, continues, "It is certain that the ear is no guide in the spelling of English, rather the reverse; and that it is almost necessary to form a personal acquaintance with each individual word."

As another example of reading made hard, let us take an American instance:—From the "Twenty-second Annual

Report of the Board of Trustees of the Public Schools of the City of Washington," we learn that in June, 1866, a spelling match was held, at which there were seven pupils selected by the teachers as the best spellers from each of the eleven intermediate schools. A gold medal had been offered by one of the trustees as a prize for the best speller. The words given out are as follows, with the number of scholars, out of a total of 77, who spelled them incorrectly:—

tambourine . . 31	indispensable. 40	bilious . . . 46	pamphlet . . . 3
complacent . . 24	susceptible . 14	niche . . . 36	labyrinth . . 42
millinery . . . 21	vignette . . . 44	cedilla . . . 28	ferrule . . . 13
varioid . . . 52	inveigh . . . 6	horologe . . 47	facile . . . 46
caterpillar . . 25	pleurisy . . . 20	exorbitant . 31	medicine . . . 4
physiology . . 16	gauge . . . 20	ellipse . . . 20	flageolet . . 28
lettuce . . . 2	pallet . . . 17	hierarchy . . 20	zephyr . . . 9
aloes . . . 16	palate . . . 17	periphery . . 50	rigid . . . 21
villain . . . 27	palette . . . 48	militia . . . 16	lacquer . . . 23
omelet . . . 27	scurrilous . . 51	dahlia . . . 30	vituals . . . 8
billiards . . . 5	aeronaut . . . 49	separate . . 14	surcingle . . 35
ghoul . . . 39	paroxysm . . 32	miniature . . 29	punctilious . 33
irresistible. . 31	daguerreotype 34		

These words were taken from the spelling-books used in the schools. The following are amusing illustrations of the modes of spelling some of the words:—

vereloid	errenaut	skurrelous
variloid	erenote	squerulous
veryaloid	airanaut	scurulous
veraloid	eranoch	scournless
valeloid	arenaught	scirilous
veri O Lord	erenolt	scuroleus
fariloid	erroenort	scurrus
variloyd	eronaut	skireles
bareloyd	aregnout	scurels
barierloid	ereunaut	skirrellous
barryaloid	airinought	schourals
marioloyd	earonaut	scurulous
	arenarch	schurrulous
	aranult	
	erynort	
	arinought	
	arroneut	

A second trial was found necessary, when the medal was awarded to Hattie E. Gove, eleven years of age, of the First District.

"These facts," says the Report, "are presented to show the importance of greater attention being given to this branch of education, so that such a report may never again be presented." What a satire is this on our system of spelling!

The state of the case has been well put in the double statement that no Englishman can tell with certainty how to pronounce any word which is presented to him in the ordinary orthography, unless he has heard it uttered by

others, and no Englishman can tell with certainty how to spell a word with which he is not already familiar in its printed form. In both cases he may *guess*, and his guess will sometimes be right and sometimes be wrong; but in neither case can he attain certainty. The anomalies of English are so great and manifold that it is difficult to exhibit them in a brief compass.

The object of all alphabetic writing is the representation of spoken sounds. For this purpose it is essential that we should have a symbol for each sound, and that that symbol should be used with regularity and consistency. An analysis of the spoken sounds of our language shows that we have thirty-eight distinct sounds, and for the representation of these we have 26 letters, 3 of them mere duplicates. This has led to the device of using two or more letters to indicate a single sound. Had this been done with uniformity all would have been well, but unfortunately no system has been followed. Thus, an examination of 3000 monosyllables showed 145 different methods of indicating the twelve vowel sounds existing in the language. Again, every letter in the alphabet except *j* is mute in some words. Why should we take the useless trouble of writing *b* in the word *lamb*, seeing that the sound *b* is never heard in it? If we take the entire range of English vowels, we shall find that there are 110 combinations of our imperfect symbols, and that they have 353 meanings. Taking the consonants in the same way, there are 119 combinations having 251 meanings. There are forty ways of representing the vowel sound heard in the word *eel*; there are nineteen ways of writing *k*, *s*, and *n*; there are 26 ways of expressing the vowel heard in *isle*, and there are 37 expedients for showing the vowel in *it*.* Of the many sounds which are hidden under the same symbol, most of us have had ample experience. The difficulties of knowing what sounds to attach to the symbols are equally great

As a Frenchman once found when he tried to explain
His complaint, for the spelling so bothered his brain
That he said to the doctor, "I've got a bad cow;"
When the doctor could only reply by a bow.
Again he attempted, "I've got a bad coo;"
But the doctor was dumb. Seeing that would not do,
He bethought him again, "I've got a bad co;"
And he thought that the doctor was terribly slow.

* For a thorough exposition of the thousandfold anomalies of English orthography, we may refer to "A Plea for Phonetic Spelling," by ALEXANDER JOHN ELLIS, B.A. 2nd. ed.; 1848. In this work, all the objections which have been raised against a reformed system of spelling are not only anticipated, but refuted with a clearness and fulness which leaves nothing to be desired.

But he tried it once more, "I've got a bad cuff;"
 The doctor lost patience and said in a huff,
 "If thus you go on I must take myself off."
 "That's it," cried the Frenchman, "I have got a bad cough."

Now it must be recollected that each of these methods of pronouncing the word cough is sanctioned by the usage in other cases. The analogies of English spelling will justify any absurdity. Take this sentence as an example: "Igh bat ai nyou kought frachm mhy taighlor too-deig."*

Igh	= I,	as in	nigh,
bat	= bought	„	fall,
ai	= a	„	plaid,
nyou	= new	„	you,
kought	= coat	„	though,
frachm	= from	„	yacht,
mhy	= my	„	rhyme,
taighlor	= tailor	„	straight,
to	= to	„	foot,
deig	= day	„	reign.

Let common sense decide. If it is reasonable to represent the vowel *I* by the combination *Igh* in one case, it is reasonable to do so in all. It would only weary to repeat instances of the absurdities of our spelling. They meet us at every turn. If candidates for employment in the Civil Service, who have in most cases been carefully prepared for the ordeal, fail to learn how to spell, what must be the condition of those to whom hard fortune has denied the chance of any large amount of education? How many in the working-classes there must be to whom reading in place of being a solace for the hours of relaxation, and a pleasant method of acquiring knowledge and wisdom, is a thing avoided from the difficulties which beset it.†

This hindrance to the cause of national education, and to the progress of our language abroad having been dwelt upon at some length, it only remains to point out the remedy. Various schemes have from time to time been put forth, but the only one to which attention need now be directed is that advocated by Mr. Isaac Pitman, of Bath. Mr. Pitman, as all the world knows, is the inventor of a very beautiful

* *Phonetic Journal*, xxx., 426.

† Every one must at times have received letters which show how hopeless is the task of the teachers of elementary schools. I transcribe the body of a letter from a young woman, relating to a fellow-servant:—I ham very soory I cannot come to see yu as I ham soo Bessey But I can say that the gril his cleane honest and industers as A tow year good charaftar from her last place she his 202 years of age [a startling assertion! The meaning of course is 20+2=22] good temperd and stady.

system of shorthand. Unlike all other stenographies, Phonography is based upon a philosophical analysis of the sounds in the English language, and this analysis has been made the basis of a new Phonetic English Alphabet, in which each sound is indicated by one letter, and each letter is attached to one sound only. In the construction of this alphabet, Mr. Isaac Pitman and Mr. A. J. Ellis, F.R.S.—a man of profound scholarship—were joint-workers.

Since 1843 various modifications have been made in this alphabet, sometimes of doubtful expediency, but always with the single object in view of making it as perfect as possible.

The sanguine expectations of its promoters have not been realised. Mr. Ellis, indeed, appears to have given up all hope of seeing a practical phonetic alphabet adopted, and now proposes a system of digraphs in place of fresh letters, for use concurrently with the old system. This system is much more complicated and cumbersome than the Phonetic alphabet, though infinitely preferable to the present want of system.

Mr. Ellis's Glossic is a new concurrent system of spelling, intended to remedy the defects, without interfering with the use, of existing English orthography.

Key to English Glossic.

Read the large capital letters always in the senses they have in the following words, which are all in the usual spelling except the three underlined, meant for *foot*, *then*, *rouge*.

BEET	BAIT	BAA	CAUL	COAL	COOL
KNIT	NET	GNAT	NOT	NUT	<u>FUOT</u>
HEIGHT	FOIL	FOUL	FEUD		
YEA	WAY	WHEY	HAY		
PEA	BEE	TOE	DOE	CHEST	JEST
KEEP	GAPE				
FIE	VIE	THIN	<u>DHEN</u>	SEAL	ZEAL
RUSH	<u>ROUZHE</u>				
EAR	R'ING	<u>EARR'ING</u>	LAY	MAY	NAY
SING					

R is vocal when no vowel follows, and modifies the preceding vowel, forming diphthongs, as in PEER, PAIR, BOAR, BOOR, HERB.

Use R for R', and RR for RR', when a vowel follows, except in elementary books, where *r'* is retained.

Separate *th*, *dh*, *sh*, *zh*, *ng* by a hyphen (-) when necessary.

Read a stress on the first syllable when not otherwise directed.

Mark stress by (·) after a long vowel or *ei*, *oi*, *ou*, *eu*, and after the first consonant following a short vowel.

Mark emphasis by (·) before a word.

Pronounce *el*, *em*, *en*, *er*, *ej*, *a*, obscurely, after the stress syllable.

When three or more letters come together of which the two *first* may form a digraph, read them as such.

Letters retain their usual names, and alphabetical arrangement.

Words in customary or NOMIC spelling occurring among GLOSSIC, and conversely, should be underlined with a wavy line ~~~, and printed with spaist leterz, or else in a different type.

Spesimen ov Ingglish Glosik.

OBJEKTS.

Too fasil'itait Larning too Reed.

Too maik Larning too Spell unnes'eseri.

Too asim'ilait Reeding and Reiting too Heerring and Speeking.

Too maik dhi Risee'vd Proanunsiai'shen ov Ingglish akses'ibl too *aul* Reederz, Proavin'shel and Foren.

MEENZ.

Leev dhi Ould Speling untuch't.

Introadeu's along' seid ov dhi Oald Speling a Neu Aurthog'rafi, konsis'ting ov dhi Oald Leterz euzd in-vai'rriabli in dhair best noan sensez.

Emploi' dhi New Speling in Skoolz too Teech Reeding in *boath* Aurthog'rafiz.

Alou' eni Reiter too reit in dhi Neu Speling *oanli* on aul okai'zhenz, withhou't loozing kaast, proavei'ded hee euzez a Risee'vd Proanunsiai'shen; dhat is—

Aknol'ej dhi Neu Speling konkur'entli widh dhi Oald.

Mr. Melville Bell's is probably the most philosophical system yet invented for the representation of vocal sounds, but its chances of adoption as the vehicle of English are too remote to need more than passing allusion.

Various other schemes, more or less thorough, have been devised for remedying the defects of English orthography, but none of them have attained the same importance as Mr. Pitman's proposals. The immense circulation of his shorthand has had the effect of familiarising the public mind with the theory of phonetic analysis and representation. For a generation he has spread information on the subject, and gathered round him a band of devoted adherents and disciples. His system is now the only system of phonetic English which has any chance of success. There is a yearly-increasing literature printed in it, and it may be hoped that the present national feeling in favour of education will aid its promoters against the present education-hindering system.

It may appear a sweeping change to alter the form and aspect of the language, but the change is by no means so violent as it seems. Changes in spelling are constantly taking place, but they are alterations which come about by hazard and without system.

If other nations have succeeded in reforming their orthography, and we know this to be the case with the Dutch

THE PHONETIC ALPHABET.

The Phonetic Alphabet consists of 38 letters, namely, the 23 useful letters of the common alphabet (*c, q, and x* being rejected), and the 15 new ones below. The vowels *a, e, i, o, u* have invariably their short sounds, as in *pat, pet, pit, pot, put*. All the other old letters have their usual signification. The italic letters in the words in the fourth line denote the SOUNDS of the letters.

VOWELS.			DIPHTHONGS.			CONSONANTS.		
A a,	E e,	I i:	Œ œ,	U u.	Ɔ ɔ,	H h,	Σ s,	W w.
A a,	E e,	I i:	Œ œ,	U u.	Ɔ ɔ,	H h,	Σ s,	W w.
Æ æ	æ æ	Œ œ	Œ œ	Œ œ	Ɔ ɔ	h h	Œ œ	Œ œ
alms, age, air, eat:			all, ope,	by, new.	chair,	thin,	then, shoe, vision,	sing.
amz, ej, er, it:			ol, ep,	bj, nu.	ger,	tin,	den, fun, vizon,	sig.

The order of the Phonetic Alphabet, and the names of the letters are—

CONSONANTS:—p, b; t, d; g, j; k, g; f, v; ʃ, d; s, z; ʒ, ʒ; m, n, ŋ; l, r; w, y: h.
pee, bee; tee, dee; chay, jay; kay, gay: ef, vee; ith, thee; es, zee; ish, zhee: el, ar: way, yay: aitch.

VOWELS:—a, æ; e, ε; i, i; o, o; y, σ; u, u.
at, ah; et, eh; it, ee: ot, awe; ut, oh; öht, oo.

FOREIGN SOUNDS:—FRENCH Ɔ œ, U u, W w, X x, Y y; GER. X x, Y y.
as in jéne, du, dū, an; ich, Sieg.

A VIEW OF THE PHONETIC

IN VARIOUS STYLES OF WRITING AND

CONSONANTS.									
Examples	Roman.	Old English.	Italic.	Script.	Short-hand.	Name.	Examples	Roman.	Old
peep	P p	Ʒ p	P p	Ʒ p	∖	pee	pat	A a	
bib	B b	Ʒ b	B b	Ʒ b	∖	bee	alms	ʌ s	
tight	T t	Ƨ t	T t	Ƨ t		tee	pet	E e	
deed	D d	Ƨ d	D d	Ƨ d		dee	age	ɛ ɛ	
church	C c	Ƨ c	C c	Ƨ c	/	chay	pit	I i	
judge	J j	Ƨ j	J j	Ƨ j	/	jay	eat	ɪ i	
cake	K k	Ƨ k	K k	Ƨ k	—	kay	pot	O o	
gig	G g	Ƨ g	G g	Ƨ g	—	gay	all	ʌ ʌ	
faith	F f	Ƨ f	F f	Ƨ f	∖	ef	but	ʌ ʌ	
valve	V v	Ƨ v	V v	Ƨ v	∖	vee	old	ʌ ʌ	
bath	H h	Ƨ h	H h	Ƨ h	(	ith	put	U u	
bathe	Ĥ ĥ	Ƨ ĥ	Ĥ ĥ	Ƨ ĥ	(	thee	ooze	U u	
sauce	S s	Ƨ s	S s	Ƨ s	o)	ess	The diphthongs written by the single letters The Phonetic Alphabet letters of the common new ones. The vowels as in <i>put</i>, <i>pet</i>, <i>pit</i>, &c. signification. SPECIMEN Bi de Fone me bi tot tu buds, in fri strɔksɔn,—a yirz ov toil bi wil not hel de ful masɔn for		
size	Z z	Ƨ z	Z z	Ƨ z	o)	zee	my	ɪ j	
ship	ʒ ʒ	Ƨ ʒ	ʒ ʒ	Ƨ ʒ	∖	ish	new	U u	
azure	ʒ ʒ	Ƨ ʒ	ʒ ʒ	Ƨ ʒ	∖	zhee			
maim	M m	Ƨ m	M m	Ƨ m	(	em			
noon	N n	Ƨ n	N n	Ƨ n	(	en			
sing	Ŋ ŋ	Ƨ ŋ	Ŋ ŋ	Ƨ ŋ	∖	ing			
lull	L l	Ƨ l	L l	Ƨ l	(	el			
roar	R r	Ƨ r	R r	Ƨ r	∖	ar			
way	W w	Ƨ w	W w	Ƨ w	∖	way			
yea	Y y	Ƨ y	Y y	Ƨ y	∖	yea			
hay	H h	Ƨ h	H h	Ƨ h	9/	aitch			

A VIEW OF THE PHONETIC ALPHABET, IN VARIOUS STYLES OF WRITING AND PRINTING.

CONSONANTS.							VOWELS.						
Examples	Roman.	Old English.	Italic.	Script.	Short-hand.	Name.	Examples	Roman.	Old English.	Italic.	Script.	Short-hand.	Name.
peep	P p	Þ þ	P p	P p	—	pee	pat	A a	Ǽ æ	A a	Ǽ æ	—	at
bib	B b	B b	B b	B b	—	bee	alms	A s	Ǽ æ	A a	Ǽ æ	—	ah
tight	T t	T t	T t	T t	—	tee	pet	E e	E e	E e	E e	—	et
deed	D d	D d	D d	D d	—	dee	age	E e	E e	E e	E e	—	eh
church	C c	C c	C c	C c	/	chay	pit	I i	I i	I i	I i	—	it
judge	J j	J j	J j	J j	/	jay	eat	I i	I i	I i	I i	—	ee
cake	K k	K k	K k	K k	—	kay	pot	O o	O o	O o	O o	—	ot
gig	G g	G g	G g	G g	—	gay	all	O o	O o	O o	O o	—	aw
faith	F f	F f	F f	F f	—	ef	but	S s	S s	S s	S s	—	ut
valve	V v	V v	V v	V v	—	vee	old	O o	O o	O o	O o	—	oh
bath	H h	H h	H h	H h	(	ith	put	U u	U u	U u	U u	—	ööt
bathe	H h	H h	H h	H h	(	thee	ooze	W w	W w	W w	W w	—	öö
sauce	S s	S s	S s	S s	o	ess	DIPHTHONGS.						
size	Z z	Z z	Z z	Z z	o	zee	my	F i	F i	F i	F i	v	eye
ship	S s	S s	S s	S s	—	ish	new	U u	U u	U u	U u	^	you
azure	Z z	Z z	Z z	Z z	—	zhee	The diphthongs in "ay (yes), boy, boil, now, noun," are written by the single letters that represent their elements, thus: ai ^v oi [^] ou [^] The Phonetic Alphabet consists of 38 letters, namely, the 23 useful letters of the common alphabet (c, q, and x being rejected,) and 15 new ones. The vowels a, e, i, o, u have invariably their short sounds, as in put, pet, pit, pot, put. All the other old letters have their usual signification. SPECIMEN OF PHONETIC PRINTING. Bi de Fonetik Alfabet eni person, öld or yşş, mē bi töt tu rid, bē in fōnetik and in ordinari buks, in tri mōnts,—ai, ofen in twenti ourz' instrskjon,—a task whig iz rerli akomplift in tri yirz ov toil bi de öld alfabet. Whot fsder or tiger wil not hel dis gret buun tu edukejon?—dis pouerful mafin for de difuzon ov nolej!						
maim	M m	M m	M m	M m	—	em							
noon	N n	N n	N n	N n	—	en							
sing	W w	W w	W w	W w	—	ing							
lull	L l	L l	L l	L l	—	el							
roar	R r	R r	R r	R r	—	ar							
way	W w	W w	W w	W w	—	way							
yea	Y y	Y y	Y y	Y y	—	yea							
hay	H h	H h	H h	H h	—	aitch							

Luke 6. 20-45.

20 And hi lifted sp hiz iz on hiz disipelz, and sed, Blesed bi yi puur for ur'z iz de kingdom ov God.

21 Blesed ar yi dat hşnger nou: for yi fal bi fild. Blesed ar yi dat wip nou: for yi fal laf.

22 Blesed ar yi, when men fal het u, and when de fal separat u from der kşmpañi, and fal reproc u, and kast out ur nem az ivil, for de Sşn ov man'z sek.

23 Rejois yi in dát de, and lip for joi: for, behold, ur reword iz gret in heven: for in de lik maner did der fsderz şntu de profets.

24 Bşť wş şntu u dat ar rig! for yi hav resivd ur konsşleşon.

25 Wş şntu u dat ar ful! for yi fal hşnger. Wş şntu u dat laf nou! for yi fal mern and wip.

26 Wş şntu u, when ol men fal spik wel ov u! for sş did der fsderz tu de fols profets.

27 Bşť i se şntu u whig hir, Lşv ur enemiz, duu gud tu dem whig het u.

28 Bles dem dat kşrs u, and pre for dem whig despřtfuli uz u.

29 And şntu him dat smřteť di on de wşn cik ofer olşş de şder; and him dat tekeť awe di klek forbid not tu tek di ket olşş.

30 Giv tu everi man dat askeť ov di; and ov him dat tekeť awe di gudz ask dem not agen.

31 And az yi wud dat men jud duu tu u, duu yi olşş tu dem likwiz.

32 For if yi lşv dem whig lşv u, whot řank hav yi? for sinerz olşş lşv đoz dat lşv dem.

33 And if yi duu gud tu dem whig duu gud tu u, whot řank hav yi? for sinerz olşş duu řven de sşm.

34 And if yi lend tu dem ov hum yi heř tu resiv, whot řank hav yi? for sinerz olşş lend tu sinerz, tu resiv az mşř agen.

35 Bşť lşv yi ur enemiz, and duu gud, and lend, heřing for nşřig agen; and ur reword fal bi gret, and yi fal bi de řildren ov de Hřest: for hi iz křnd şntu de şnřankful and tu de ivil.

36 Bi yi derřer mersiful, az ur fsder olşş iz mersiful.

37 Jşř not, and yi fal not bi jşřd: kondem not, and yi fal not bi kondemd: forgiv, and yi fal bi forgiven:

38 Giv, and it fal bi given şntu u; gud mezur, prest down, and řeken tşgeder, and řşnig şver, fal men giv intu ur buozom. For wid de sem mezur dat yi mřt widol it fal bi mezurd tu u agen.

39 And hi spek a parabel şntu dem, Kan de blřnd lid de blřnd? fal de not bşť fol intu de diř?

40 De disipel iz not abşv hiz master: bşť everiwsn dat iz perfekt fal bi az hiz master.

41 And whi behşldest đou de mřt dat iz in di brşder'z ř, bşť persivest not de bim dat iz in đřn řn ř?

42 řder hou kanst đou se tu di brşder, Brşder, let mi pul out de mřt dat iz in đřn ř, when đou đřself behşldest not de bim dat iz in đřn řn ř? řou hipokrit, kast out ferst de bim out ov đřn řn ř, and den falt đou si klřrli tu pul out de mřt dat iz in di brşder'z ř.

43 For a gud tri brřeť not ferř kşrspt frut; nřder đşť a kşrspt tri brř řerř gud frut.

44 For everi tri iz nen bi hiz řn frut. For ov řornz men duu not gader řřgz, nor ov a brambel buř gader de greps.

45 A gud man out ov de gud trezur ov hiz hart brřeť ferř đát whig iz gud; and an ivil man out ov de ivil trezur ov hiz hart brřeť ferř đát whig iz ivil; for ov de abşndans ov de hart hiz mřuf spiket.

and the Spanish, surely we may hope for success also in the same undertaking.* And when that day comes on which we have swept away what Max Müller has well called "our corrupt and effete orthography," we shall have destroyed the last and only barrier which prevents English from being the language of the world.†

Surely that is a future so great and glorious that we need not hesitate at any trouble which will hasten the day. We have already achieved much. The flowers that first grew beside the Avon, now bloom alike on the banks of the sacred Ganges, and by the margin of the broad Mississippi. The lays of merry England are heard alike in the fair Derbyshire dales and on the plains of the Far West. The thoughts of our great thinkers, the songs of our poets are no longer bounded by the narrow seas that hem in our island home. They fly to every point of the compass, and

* One of the first undertakings of the Real Academia Espanola was to reform the Spanish spelling, to make it uniform in principle and easy in practice. The first of the rules laid down was, that "the pronunciation of a word should be the sole and universal rule for its orthography, when it is sufficient to determine the various letters." The result is that "the orthography of Spanish at the present day leaves little for the phonetician to desire, as it suffices to determine the pronunciation of every word with ease and certainty." Dutch spelling was re-modelled by Professor Siegenbeek, and since 1806 it has been required by the Government that all public documents should be written by his system. Polish, Bohemian, and Magyar have modern alphabets, and are constructed on strictly phonetic principles.—ELLIS, "Plea," pp. 59, 60.

† The literature of spelling-reform is already extensive. The following represent the most important proposals:—

"A Plea for Phonetic Spelling; or, the Necessity of Orthographic Reform." By ALEXANDER JOHN ELLIS, B.A. Second edition. London, 1848. 8vo.

"The Essentials of Phonetics, containing the theory of a universal alphabet, together with its practical application as an ethnical alphabet to the reduction of all languages written or unwritten, to one uniform system of writing." By ALEXANDER JOHN ELLIS, B.A. London, 1848. 8vo. This is printed in the "Phonetic Alphabet" of 1847.

"On Early English Pronunciation, with especial reference to Shakspeare and Chaucer, containing an investigation of the correspondence of writing with speech in England from the Anglo-Saxon period to the present day, preceded by a systematic notation of all spoken sounds by means of the ordinary printing types." By ALEXANDER J. ELLIS, F.R.S., F.S.A. 1869-71. Parts 1 to 3.

"A Defence of Phonetic Spelling, drawn from a history of the English alphabet and orthography, with a remedy for their defects." By R. G. LATHAM, M.A., M.D., F.R.S. Bath, 1872. 8vo.

"The Universal Language," an argument for the reformed orthography, as a means of aiding the universal diffusion of the English language. By WILLIAM WHITE, Bath. 12mo., pp. 16.

Mr. Isaac Pitman has for thirty years printed a Phonetic Journal, which has now become a repository of nearly everything of importance that has been issued on the subject. He has also issued numerous tracts in advocacy of his proposals.

"Visible Speech the Science of Universal Alphabetics," or self-interpreting physiological alphabetics for the writing of all languages in one alphabet. By ALEXANDER MELVILLE BELL. London, 1867.

find everywhere audiences not few but fit. In the Australian sheep-walk, amid the tropical glories of Jamaican scenery, in the glowing valleys of the Polynesian islands, east, west, north, or south, we find the restless energetic Englishman. It is not a thing to be lightly thought of, this wide extension of our English tongue.

Our language is a beautiful casket, shining with gold and glittering with gems, and enclosing still more precious, still more costly jewels. Wherever the Englishman goes he carries with him the energy, the love of order, the purity of home-life, the independence, the freedom of thought, of speech, of action, which have made England not only great and prosperous, but the "august mother of free nations." The language is the best test of national capacity. It expresses not only the exact extent of the nation's knowledge, but also its spiritual condition and moral aspirations. Apart from all national vanity, we may rejoice that Shakspeare's language is going forth to the ends of the earth. It bears with it the science of Newton and the politics of Adam Smith. It bears with all that is purest and best in the teachings of the ancient world. It bears with it countless memories of heroic deeds. It bears with it those aspirations after Liberty and Right which are the most precious possession of our race. May it go forward conquering and to conquer, resistless in its power and majesty, until it becomes a new bond of peace and brotherhood amongst all the nations, until earth's fertile valleys shall glow with fruits and flowers, and "the desert shall rejoice and blossom as the rose."

IX. THE SCIENTIFIC ASPECT OF THE INTERNATIONAL EXHIBITION, 1873.

THE exhibitions at South Kensington, in their annual occurrence, are losing much of their novelty, and are assuming that business character which must be essential to their wholesome effect upon the national industry. An Englishman in all he does is always very much in earnest, and our exhibitions have been characterised throughout by a determination not "to play at work." In "going to the Exhibition" there is something indicative of real work, very different to the idea that obtained with the "World's Show" of 1851. As a record of progress,

scientific, artistic, or commercial, our exhibitions have thrived best, and not as a place of recreation. So that one is not astonished at the serious, business-like aspect of the now familiar galleries, which present amongst their contents perhaps not so much novelty, but certainly quite as much interest as the exhibits of former years.

It is perhaps premature to speak of the effects of these institutions upon the industrial classes, but doubtless many of our readers will have remarked,—and nowhere is it more apparent than at the exhibition itself,—the increased interest and desire for information. It should be remembered that the number of visitors attending the exhibition of the present year represents very nearly the proportion who attend for the purposes, not of recreation, but to satisfy the desire to acquire knowledge. The novelty has long ago worn off. The largeness of the attendance is most encouraging, and evinces a permanent and wide-established wish to maintain our national commercial standard.

Another and not less important feature is the increased value of our colonial exhibits, regarded from an artistic and adaptable point of view. These exhibits have been following a steady course of development, especially in independence of character. And if we look upon our colonial possessions as outposts in the English army of civilisation, we shall derive much profitable pleasure from the contemplation of their improvement.

Considering the attractions of the Vienna Exhibition, the portion of our exhibition absorbed by continental exhibitors is most creditable to the industry and perseverance of our authorities, for many very interesting works and processes come from abroad.

The portion of the exhibition possessing the greatest interest to the general scientific visitor is the machinery departments and their adjuncts. And here there is this year an exhibit of the highest order of merit,—the rearing of the silkworm, and the processes of preparing, spinning, and weaving silken fibre. Immediately outside the machinery department is a quiet, neat tent, containing, on trays supported by a framework in the centre of the structure, many thousand silkworms. Here the development of this wonderful and valuable insect is witnessed upon a commercial scale, as exhibited by M. Alfred Roland, of Orbe, Switzerland. Returning to the machinery department, we stand in front of M. Jouffray's (Rue Vimaine, Vienna) apparatus for unwinding the cocoon of the silkworm. The establishments in which the unwinding is carried on are

termed "filatures;" and the machinery consists of ordinary reels driven sometimes by a falling weight, or machinery of a very crude order. Here, of course, steam is employed. A table with a brass top contains shallow tinned-copper boilers, about a foot in diameter, and nine inches in depth. One of these boilers is heated by steam, and on the surface of the water there float several score of cocoons. A whisk of peculiar shape is immersed in the water by the operator, and rapidly rotated; when withdrawn from the water there are attached to the whisk several of the ends of the cocoons, and these fibres are passed to the reel. A most important part of the process consists in maintaining a constant supply of fibre to this compound thread from the unattached cocoons. The compound fibre passes over a circular glass hook to a horizontal bobbin, upon which it is wound, motion being imparted to the bobbin by a small wooden roller on the bobbin-spindle. This "winding" machine, as well as the "cleaning," "doubling," and "spinning" machines, are exhibited by Messrs. Rushton, Sons, and Co., of Macclesfield. The "cleaning" machine next takes up the silk, and transfers it to another bobbin. During its passage, the silk passes between two fixed parallel plates close together. By this means any irregularity or knot in the fibre is detected. In the doubling machine the fibres from two or three bobbins are wound side by side, without twisting, on to one bobbin. A very neat contrivance is employed to detect a break in any one of the fibres, and so to prevent inequality in the thickness of the silk. The breaking it would be tiresome to detect by the eye, because the filaments are so fine as to be difficultly visible. The filament is passed through an eye in the end of a wire, and supports this wire. Should the filament break, the wire falls, and liberates a friction cam, which, pressing against the bobbin, stops it. On the spinning machine the compounded fibre from the doubling machine is twisted, and this spinning is completed by a fifth machine, whence the silk proceeding is commercially known as "tram" and "organzine," according to the mode of its spinning. "Tram" is the term applied to the fibres with a minimum of twist, and "organzine" to those with a maximum twist. The twists are about twenty to the inch of thread. The silk is now handed over to the dyer, who, in turn, when his processes are complete, forwards it to the weaver. But before the dyer takes the silk in hand, a piece of mechanism known as the "snail cam" is employed to arrange the silk in hanks. A complete set of the interesting apparatus used

in the preparation of the fibre is also exhibited by Messrs. W. Higginbottom, of Derby. Messrs. Greenwood and Batley, of Leeds, exhibit a machine for the utilisation of the waste silk of the foregoing processes, which is effected by a similar process to that employed in cotton manufacture, and described before in this journal. Messrs. Warner, Sillett, and Ramm, of Newgate Street, and Messrs. Norris and Co., of Wood Street, Cheapside, exhibit three Jacquard looms, worked by manual labour, and the design from which the cards that control the action of the machine are prepared. The design is by Owen Jones, Esq., and is divided into 5,587,200 small squares, the design to be placed on the cards being selected from these squares. It is impossible, however, to give an exhaustive account of these pieces of superb mechanism; but we may select the following from the excellent report prepared for the Society of Arts by the Rev. Arthur Rigg, M.A. "It will be observed," he says, "that at the top of these three looms there are a number of cards in which holes are perforated. The holes in each card represent some of the squares in the pattern through which the needle of an embroiderer would pass, assuming the design to be one for tapestry. To form the design exhibited, there are connected 9312 cards in three lines. These cards are laced together, and measure 1000 yards in length. The whole pack has to be turned over each time that the design is completed in the loom. Immediately under the one top card in each line of cards there is a square metal boxing, filled on all sides with small holes; in fact, honeycombed, but with square instead of hexagonal cells. These boxings are on axes, in one and the same straight line, and by means of a catch, connected with a cord on which the workman's hand or foot can act, they may be turned through one-fourth of the circumference by one motion of the hand or foot. In so turning, the perforated cards are drawn forward, each card covering one side of the square boxing, except where the holes in the cards previously alluded to are found. For this turning, the frame-work in which these boxes rotate is caused to move on one side. If the cards and the square boxings were taken away, there would be seen a number of wires projecting horizontally from a series of openings in a fixed metal framing. Each of these wires is held forward by means of light coiled springs at the back ends of them. If now the square boxings with perforated cards over the back vertical side be permitted to fall upon the projecting wires, a number of them will be pressed back against the light springs, the

remainder passing through the perforations in the cards and entering the honeycombed box. Between the visible ends and back springs each wire is bent round so as to form an eye through which a vertical wire passes. These vertical wires have hooks at the top and bottom. Cords, hereafter alluded to, are attached to the bottom hooks. The top hooks of those wires, through eyes pressed back by the cards, are thrown out of the general line; and thus, when a narrow metal slip is raised by the hand or foot of the workman, those vertical wires only are raised which remain in the normal line, and therefore those lower hooks only are moved which form part of these wires. A number of cords pass from the warp to these hooks; concealed by the numerous threads of the warp are small delicate little glass frames, each containing six very closely-formed eyes, placed vertically over one another; to the top eye a cord from a hook is attached—through the next four eyes four adjoining threads of the warp pass,—to the lower eye is fastened a cord with a light leaden weight; thus the 29,088 of the warp are passed through these eyes. When, now, the wires are raised to which cords are attached, four times that number of threads are raised. But it may be requisite that only one or two of these four should have been raised. An arrangement for this purpose is made in hanging framings of threads near the operator's hands. These framings constitute what is named "a harness;" in them every thread in the warp has an eye to itself, and therefore, by the action of these eight framings, one or more of the raised threads can be depressed or raised higher. This "harness" is not required where, as in Messrs. Stevens's (of Coventry) loom, each thread has a cord and eye to itself."

Not the least important portion of the Exhibition are the Food Processes, even if we exclude for the present Mr. Buckmaster's School of Cookery, to which we will afterwards refer. Though sweetmeats can scarcely be termed food, yet they may be conveniently classed as an adjunct; and it will be better, as following next in catalogue order, to inspect the machinery and processes employed in the manufacture of sugar confectionery exhibited by Messrs. F. Allen and by Messrs. Hill and Jones. These machines consist essentially of immense copper pans revolving eccentrically, which contain the seeds or almonds to be sugared. Liquid sugar is admitted to the seeds or almonds, and these kept constantly rolling by the motion of the pans are soon covered with a thin coat of sugar. Sugar is again added, until a sufficiently thick coat is obtained. The resulting sugar-

almonds or carraway comfits are coloured, if required, by the introduction of colouring matter into the pan during the final coating. A description is given, although the process is not yet shown (by Messrs. Hill and Jones), of the method by which essences and liqueurs are confined within sugar vessels:—Shallow trays, about fifteen inches wide, are filled with starch flour. A “strike,” or levelling edge is drawn over, and the surface thereby smoothed. On the under side of a narrow board, about eighteen inches long and four inches broad, are fastened a number of plaster-of-Paris moulds, of the forms to be made. These narrow boards are laid on the starch flour again and again, until the surface is indented with the designs. A pan of clarified sugar, at such a temperature and consistency as the workman deems suitable, is added to it and well stirred in the non-crystallisable liquid. Each design is thus filled with a crystallisable and non-crystallisable substance, and the manufacturer takes advantage of a physical law, that under these conditions the crystalline element squeezes into the interior the non-crystalline one. Mr. Rigg thinks this method of making confectionery suggestive of the vesicular cavities coming under the notice of the geologist and mineralogist in agates, &c., and he refers to Nicol’s paper, “On Fluid in Minerals,” given in the “Edinburgh Philosophical Journal,” for 1828-9.

Near at hand, Messrs. Tulloch and Co. exhibit some cocoa-flaking machinery, the cocoa being forced between a fixed edge and a rotating disc. Messrs. Tallerman show their process of preserving meat by the immersion of the cases containing the meat in chloride of calcium. Messrs. Criscuolo, Kay, and Co. have a very interesting exhibit illustrating the method of manufacturing macaroni, in which Semolina wheat is kneaded into a dry dough, the dough being forced through a heated cylinder, and then through apertures of the size the macaroni is intended to assume, whence it is taken to the drying-room. Another apparatus for preparing cocoa is shown by the Compagnie Francaise. Farther on is the machinery devised by Messrs. Colman for separating pure mustard from the seed, and a most noisy exhibit it is. The seed is first crushed between steel rollers, and then in a stamping mill, whence it is transferred to a series of sieves shaken by mechanical means. At the same time is shown the method of constructing the canisters and the cases in which these are packed. Messrs. Car and Cunningham exhibit a “disintegrating flour mill,” and Messrs. Batty the preparation of oranges for marmalade.

The manufacture of aërated waters is always a matter of interest, and the visitor will be well rewarded by a study of the machines and methods exhibited by Messrs. Hayward, Tyler, and Co., by Messrs. Barnet and Foster, and by Messrs. Fleet and Co. The chief difference in these methods is in closing the bottles. By Messrs. Barnet and Foster the bottle is closed with a marble pressed against an india-rubber welt by the force of the gas, while Messrs. Hayward and Co. employ a wooden plug to effect the same purpose.

We may class together the peculiar machinery employed in working or crushing stone. First, in catalogued order, there is an exhibit by the Diamond Rock Boring Company of their drills for mining, quarrying, &c. The black hard carbons are fixed in a collar at the end of a tube, and are made to rotate on the face of the rock to be bored. Messrs. H. R. Marsden exhibit a machine for crushing ores or breaking stones, consisting in the application of corrugated powerful jaws to this purpose. But by far the most unique exhibit is the sand-blast of Messrs. Tilghman, which has already been described in the pages of this journal. It will not, however, be uncalled for to give again the principles of this invention. The force employed is the abrading action of minute particles of sand (impelled by a steam or air-blast) when brought into contact with a hard, resisting surface, as that of stone, glass, &c. By covering the portion of the surface which it is desired should remain uncut with a medium having but slight elasticity, as paper, india-rubber, designs may be produced upon the surface, or cut entirely through by continuing the action. The sand is admitted from a hopper into an inner tube surrounded by a steam-jet, the steam being supplied from 55 lbs. boiler pressure. In five minutes three-sixteenths of an inch of marble were cut away. In this process, by means of chromatised gelatine, photographs may be taken and cut into glass.

We must pass by the silks and velvets, for our time is running short, and there are still the surgical appliances to be seen. These are arranged in the west theatre on the balcony floor of the Royal Albert Hall, and include not only the most modern improvements, but a historical collection extending back to the time of Greek medicine. In this room the instruments, where they are not self-explanatory, need a special medical knowledge for the comprehension of their detail; and, having stopped with the visitor during his inspection of the Electric Cautery,—in which a platinum wire, raised to red or white, heated by the galvanic current, is employed instead of a heated iron,—we may descend to the

ground floor, and take our seat in Mr. Buckmaster's Food lecture-room. Here we may learn the mysteries of preparing filleted soles and fennel sauce, or study domestic economy by ascertaining how to utilise the bones of the sole just placed upon the operating table. Mr. Buckmaster's little room is sadly disproportionate to his audience, while to our thinking it forms by no means the least important part of the Exhibition; for, although the people whom his discourse will benefit are not likely to hear him, the step is the first in the right direction, and, if supplemented by cheap or free lectures in various parts of the metropolis, would be of incalculable good.

Such, briefly, are the salient points of this year's efforts on the part of the Commissioners, and we think the visitor will find with us that these efforts have provided an excellent illustration of the healthiness of this movement for promoting the welfare of our national industries.

NOTICES OF BOOKS.

Elementary Treatise on Natural Philosophy. By A. PRIVAT-DESCHANEL. Translated and Edited, with Extensive Additions, by J. D. EVERETT, M.A., D.C.L., F.R.S.E., Professor of Natural Philosophy in Queen's College, Belfast. Part IV. Sound and Light. London: Blackie and Son. 1872.

THIS is the last part of Dr. Everett's admirable handbook. The arrangement, which we have previously noticed as methodical in the highest degree, appears in no one of the three other volumes so logical as in this. The comparison and contrast of the vibrations of light and sound are calculated to afford material assistance to the understanding of the phenomena presented successively to the student, especially in the case of the difficult problems of polarisation and interference. Under the head of Acoustics there are considered the production and propagation of sound, its numerical evaluation, modes of vibration, consonance, dissonance, and resultant tones. Under Optics the subdivisions are propagation and reflection, refraction, lenses, optical instruments, dispersion and spectra, colour, the wave theory of light, and polarisation. The chapters on the wave theory of light and the numerical evaluation of sound are particularly worthy the student's attention; and he will find the illustrations as clear, and as fine specimens of wood-engraving, as in the former parts of the work.

A Manual of Recent and Existing Commerce. From the Year 1789 to 1872. By JOHN YEATS, LL.D., &c. London: Virtue and Co. 1872.

DR. YEATS is already well known by his works on the technical and natural history of commerce, the growth and vicissitudes of commerce, &c. The title of the present work is sufficiently self-explanatory. The history is inclusive, and, as far as may be, exhaustive; it is rendered so by the author's terse style and syllogistic method. The preface states the work to be a means of preparation for the higher departments of commerce, or as affording matter for reflection during intervals of repose; that it will assist an intelligent reader in arriving at sound conclusions with regard to the credit of any single state, and aid him in a study of the present or prospective position of our own country, we fully agree. We have especially to draw attention to the history and principles of banking as exemplified in the affairs of the United States and of our own national bank. The particulars of a bank-parlour inspire an ordinary person with considerable awe; but on the perusal of such a work as this the transcendental interest speedily gives place to a deeper respect for commercial integrity and a right appreciation of the demerit of all

that tends to subvert a system of honourable economy, all the reckless venture too often witnessed as the cause of monetary panic. Dr. Yeats's works would be an admirable adjunct to a chair of Commercial Economy; and it is not Utopian to express the hope that at no far distant date colleges will prepare universally for science, commerce, and the arts.

Popular Lectures on Scientific Subjects. By H. HELMHOLTZ, Professor of Physics in the University of Berlin. Translated by E. ATKINSON, Ph.D., F.C.S. London: Longmans and Co. 1873.

PROFESSOR HELMHOLTZ has been known for a number of years in the English scientific world as one of the foremost thinkers of the age, and his admirable Memoirs have from time to time appeared in the "Transactions of the Royal Society," and the "Philosophical Magazine." This is, however, the first time that any of his lectures have been brought within the grasp of the well-informed non-scientific reader. But the book will also be very acceptable to the purely scientific man, for it contains several lectures not before published. Nothing, perhaps, strikes us more in connection with our author than his varied and exact knowledge; as a pure physicist he takes a very high standing; he has done much to develop the now dominant doctrine of the Conservation of Energy; he has worked considerably in the domain of thermo-dynamics; and his acoustic researches are most remarkable and original. Again, he is a good physiologist—indeed he was a military physician in the Prussian service, before he was professor of physiology in the University of Königsberg, and he held a similar professorship in Heidelberg before he was appointed to his present professorship of physics in Berlin. Wherever points of contact have appeared between pure physical actions and purely physiological actions, he has endeavoured to trace the exact nature and course of the concurrent phenomena. His researches on the organs of sight and hearing are of high merit, and receive the admiration alike of the physicist and the physiologist. Add to all this the fact that Prof. Helmholtz is a mathematician; and, most rare of all, that he can clothe his profound generalisations, in whatever subject he may discuss, in most lucid and elegant diction, and the reader has foreshadowed before him what an intellectual feast he may expect from the work we are about to examine.

The lectures have been delivered at various times during sixteen years; one, "On Goethe's Scientific Researches," so long ago as the spring of 1853; another, "On the Interaction of the Natural Forces," in 1854; and the latest, "On the Aim and Progress of Physical Science," in 1869. As to the purport of the lectures, the author says:—"If I may claim that they have any leading thought, it would be that I have endeavoured to illustrate the essence and import of natural laws, and their relation to the mental activity of man. This seems to me the chief

interest and the chief need in lectures before a public whose education has been mainly literary."

We will now glance at the Lectures *seriatim*, premising that the first and second have been translated by Mr. H. W. Eve, of Wellington College; the third by Mr. A. G. Ellis, whose papers on musical subjects in the "Proceedings of the Royal Society" some of our readers will remember; the fourth and seventh by Dr. Atkinson, who is also editor of the series; the fifth by Dr. Tyndall; and the eighth and last by Dr. Flight.

In the first lecture, which was delivered before the University of Heidelberg in 1862, the author traces the connection between the Natural Sciences and other branches of knowledge. He commences by pointing out the extraordinary progress made during the last century in all branches of Natural Science. So long as its development was slight, we cannot wonder that it was not recognised as an educational engine, or admitted as a part of the university curriculum to take up a position side by side with the more ancient subjects:—Theology, Jurisprudence, Medicine. The astonishing activity of research has altered the condition of things. The four elements of the ancients have become sixty-four; the six planets of 1781 have increased to seventy-five; the fifteen hundred stars of the 17th century have become twenty thousand, the position of which in the heavens has been accurately determined; and so in other branches of sciences. Consequently our universities recognise these subjects now far more fully than ever before, and while in the 17th century they were often represented by one or two professors, they are now taught by seven or eight. The disruption between Moral Philosophy and Physical Philosophy may be traced to Hegel rather than to Kant, for the latter based his Cosmogony upon Newton's law of Universal Gravitation, while the former endeavoured to throw into discredit both Newton himself and the whole body of existing Natural Philosophy. Then came an open feud: "the philosophers accused the scientific men of narrowness; the scientific men retorted that the philosophers were crazy. And so it came about that men of science began to lay some stress on the banishment of all philosophical influences from their work; while some of them, including men of the greatest acuteness, went so far as to condemn philosophy altogether, not merely as useless, but as mischievous dreaming." With the Moral Sciences it was the same; they almost ignored the existence of physical science, and often denied it the very name. This opposition, however, was not long maintained; as the Natural Sciences increased in importance, they received more and more general recognition from other sources. Yet when we remember the points of dissonance between the Moral and the Natural Sciences we must admit that a perfect assimilation can never be possible: "while the Moral Sciences deal directly with the nearest and dearest interests of the human mind, and with the institutions it has

brought into being, the Natural Sciences are concerned with dead, indifferent matter, obviously indispensable for the sake of its practical utility, but apparently without any immediate bearing on the cultivation of the intellect." The author is afterwards led to compare the Natural Sciences with the other branches of learning as a means of culture. He distinguishes between the "Experimental" Sciences and the "Natural" Sciences; and asserts the advantage of the former because "they can change at pleasure the conditions under which a given result takes place, and can thus confine themselves to a small number of characteristic instances in order to discover the law." He regards the discovery of the law of gravitation as "the most imposing achievement that the logical powers of the human mind have hitherto performed." The entire discourse indicates great powers of generalisation. Such attempts to define and determine the precise extent of syncretism which shall exist between diverse sciences can only be made by master minds, which shall be excellently exact, and at the same time comprehensive, and such a mind we have in Prof. Helmholtz.

The second lecture treats of the scientific researches of Goethe. It was said of Sir Humphry Davy that if he had not been a great natural philosopher he would have been a great poet. In the case of Goethe, the poet eclipsed the natural philosopher; while the "Egmont" and "Wilhelm Meister," "Hermann and Dorethea" and "Faust" are always remembered in connection with his name, few recognise the fact that he wrote a "Beitrag zur Optik" two years before "Wilhelm Meister." He also wrote on botany and osteology. He introduced into science two important and fruitful ideas:—"The first was the conception that the differences in the anatomy of different animals are to be looked upon as variations from a common phase or type, induced by differences of habit, locality, and food." The second was "the existence of an analogy between the different parts of one and the same organic being." Goethe's theory of colour is open to much criticism, and violent controversies have raged about it.

The third lecture treats of a subject to which Prof. Helmholtz has devoted considerable attention, and which has received at his hands a notable development. It treats "of the Physiological Causes of Harmony in Music," and was delivered in Bonn during the winter of 1857. Since that time the celebrated "*Tonempfindungen*" has appeared, and we are glad to learn that this work is now being translated by Mr. Alexander Ellis, and that it will soon be published by Messrs. Longmans. In the lecture on Harmony, the author investigates the "foundation of concord." He gives us eminently scientific definitions of *musical tone, pitch, sound, and quality of tone*. The formation, progress, and interference of waves is admirably treated, and the woodcuts relating to this subject are worthy of close study (notably Fig. 2, p. 72). In concluding, the author remarks, "For

the attainment of that higher beauty which appeals to the intellect, harmony and disharmony are only means, although essential and powerful means. In disharmony the auditory nerves feel hurt by the beats of incompatible tones. It longs for the pure efflux of the tones into harmony. It hastens towards harmony for satisfaction and rest. Thus both harmony and disharmony alternately urge and moderate the flow of tones, while the mind sees in their immaterial motion an image of its own perpetually streaming thoughts and moods."

The fourth lecture treats of "Ice and Glaciers," and discusses in some detail the various views of Tyndall and others in regard to the formation of ice, the compression of snow into ice, and regelation.

In the next lecture, which was delivered in Königsberg in 1854, the author discusses the "Interaction of Natural Forces." In this we have an admirable account of the transmutation of the various so-called physical forces, and of their relationship to each other. The connection is clearly and cleverly traced, and is illustrated very happily by examples. Some of us will remember that when in 1798 Rumford boiled water by friction, he remarked that if fuel ever became scarce we could cook our food by transforming mechanical action into heat, as he had then done; we did not, however, know before that "in some factories, where a surplus of water power is at hand, this surplus is applied to cause a strong iron plate to rotate rapidly upon another, so that they become strongly heated by the friction. The heat so obtained warms the room, and thus a stove without fuel is provided." In a town like Bristol, where the rise and fall of the tide is considerable, the amount of heat which might thus be obtained from mechanical sources would be considerable; and if water-mills to produce heat by friction were placed in the Rhone, as it leaves the Lake of Geneva, all the poor of that city might have their food cooked in a public kitchen, in which the heat should be generated by purely mechanical means.

The sixth lecture is entitled "The Recent Progress of the Theory of Vision," and is translated by Dr. Pye-Smith, of Guy's Hospital. The eye is discussed from a threefold point of view: physical, physiological, and psychological; the latter treats of the mental realisation of the changes which take place in the optic nerve. In summarising the conclusions regarding the perception of sight, the author remarks that "the correspondence between the external world and the perceptions of sight rests, either in whole or in part, upon the same foundation as all our knowledge of the actual world—on *experience*, and on constant *verification* of its accuracy by experiments which we perform with every movement of our body. It follows, of course, that we are only warranted in accepting the reality of this correspondence so far as these means of verification extend, which is really as far as for practical purposes we need."

The seventh lecture is devoted to a subject which Prof. Helmholtz has largely contributed to establish and develop—the Conservation of Force. This law, which possesses a great generality of application, although partially recognised by Newton and Daniel Bernouilli, by Rumford, Davy, and others, was first enunciated in its universality by Dr. Julius Mayer, in which work he was ably supplemented by the admirable experimental results obtained by our countryman Joule. The law asserts that the “quantity of force which can be brought into action in the whole of Nature is unchangeable, and can neither be increased nor diminished.” The law has been so admirably illustrated and discussed by Tyndall and others in this country, that we need scarcely allude to the details of this lecture. We may mention, however, in passing, the fertility of illustration which the author possesses; among other experiments we notice (Fig. 47, p. 345) a means of producing fire by the simple friction of two pieces of wood after the manner of the savages, but which we have in vain tried to do even by the use of a turning lathe and two pieces of wood differing considerably in hardness.

The eighth and last lecture, on “The Aim and Progress of Physical Science,” was delivered in Innsbrück in 1869. In this the author enters into a discussion of various ideas which have—some for a longer, some for a shorter time—been floating about on the confines of recognised science. He pays an elaborate tribute of admiration to the doctrines of Darwin, discusses various questions concerning life; and is led to remark that “the recent progress of physiology and medicine is pre-eminently due to Germany.” Yet he is fain to admit that “both in England and France we find excellent investigators, who are capable of working with thorough energy in the proper sense of the scientific methods; hitherto, however, they have almost always had to bend to social or ecclesiastical prejudices, and could only openly express their convictions at the expense of their social influence and their usefulness.” This was written ten years ago. We hope Prof. Helmholtz knows how much these things have changed in England even during that short period.

Here, then, we end our notice of a book, which even in its translated form possesses, quite irrespective of the actual science which it contains, a certain charm of style and diction seldom met with in works of this nature, most seldom to be met with at the hands of exact and profound thinkers. We find here our ardent investigator, our original thinker, our profound mathematician, introducing into the most complex subjects a grace of culture and an elegance of expression which it is always satisfactory to meet with, and which indicates the man of great general as well as special knowledge. We find constant quotations from the philosophical poets of Germany; Prof. Helmholtz evidently adores “Faust,” is evidently pervaded by a spirit as full of harmony as any of those great sonatas of “the mightiest among the heroes of harmony” Beethoven.

The Life of Alexander von Humboldt. Compiled in Commemoration of the Centenary of his Birth, by J. LOWENBERG, ROBERT AVE-LALLEMANT, and ALFRED DOVE. Edited by Prof. KARL BRUHNS, Director of the Observatory of Leipzig. Translated by JANE and CAROLINE LASSELL. 2 vols. Longmans, Green, and Co. 1873.

THIS work is divided into four parts: the first and second, by Julius Löwenberg, treat of the youth and early manhood of Humboldt, and of his travels in America and Asia; the third, by Robert Avé-Lallemant, gives an account of his sojourn in Paris from 1808 to 1826; and the fourth, by Alfred Dove, describes the incidents of the meridian and decline of his life, a time included between 1827 and 1859.

It is difficult in a review to give even a skeleton biography of a man whose life was extraordinarily eventful. One does not know where to begin or where to end. The man possessed a mind of such fertility and such power of thought that he was eminent in almost every subject that he handled, and the mighty extent of his knowledge is altogether surprising. He was in every respect an intellectual giant.

The difficulties of compilation have, in this instance, been considerably increased by the singular modesty of Humboldt. He was unwilling to furnish any letters or other documents which could throw light upon his life and labours. In his will, dated May 10th, 1841, he writes—"I request that my dear relatives and friends will endeavour to prevent the appearance of any biographical notice of me, or laudatory article, in either the *Staatzeitung* or other public journal over which they can exercise any control. I have also drawn up a letter for transmission to the Institute at Paris, requesting that the *éloge* usually delivered upon the death of a foreign associate may be omitted in my case." Since the death of Humboldt several small memoirs have appeared: this, however, is by far the most complete biography of him which exists; the information has been drawn from every available source, and these are numerous, for Humboldt was a great correspondent. His letters are often of great interest and value; among them are thirty addressed to Gauss, thirty to Karsten, and no less than three hundred and thirty to Encke.

Alexander von Humboldt was the son of Major von Humboldt, and was born on September 14th, 1769; in which year also were born Napoleon, Cuvier, Chateaubriand, Canning, and Wellington. He was well educated at home by various tutors, and attended lectures on Philosophy and cognate subjects; he also studied drawing, and the arts of etching and engraving on copper. He was fond of collecting botanical and other specimens, and of classifying them. It is strange that neither Alexander nor his brother William had the smallest taste or liking for music; the

latter actually spoke of it as a "calamité sociale." As a boy Humboldt showed a great desire to travel in distant lands, and books of travel were among his favourite literature. In 1787 he matriculated at the University of Frankfort-on-the-Oder. The scientific world was at this time commencing the period of transition which had originated in the great discoveries of Lavoisier, Scheele, Priestley, Cavendish, and others. A good deal of false science was readily received by the Academies: thus Semler communicated to the Berlin Academy a means of producing gold, by keeping a certain volatile salt in a warm and moist condition for a sufficient length of time. Silberschlag had recently delivered lectures on the sun before the Academy, in which he asserted that—"The sun is really a kitchen-fire, and the spots are clouds of smoke and great heaps of soot; consequently where there is a kitchen-fire there must be meat to roast, such as godless people,—Deists, Universalists, and Atheists,—and the devil is the cook who turns the spit." Many of Humboldt's earlier ideas on Physical Science were obtained by attending the lectures of Marcus Herz, a Jewish physician, and ardent disciple of Kant, who commenced the lectures in his 80th year. Humboldt appears to have been very industrious while at Frankfort. In 1789 he went to the University of Göttingen, staying by the way at Helmstädt, to see Prof. Beireis and his wonderful museum. He gives a curious account of the Professor:—"At home he is always engaged in prosecuting discoveries, and just now, as Crell assures me, he spends sixteen hours a-day in reading on various subjects. Besides the European languages, he speaks Egyptian, Chinese, Japanese, as well as some of the dialects of Northern India, and he read out to me with facility, in German, some passages from a Japanese book, yet many people venture to doubt whether he knows Hebrew! He is, in short, a most extraordinary man, who, with the most profound knowledge of Chemistry and Numismatics, combines the charlatanry of the most cunning juggler. . . . He tells me that he can make corn to grow, that he knows of a tree that bears truffles, that he lives without sleep, and in conversation says every minute that 'he has thought upon that subject for six weeks together without eating or drinking.'"

At this time the University of Göttingen was a celebrated centre of Science, and after Science it was renowned for its teaching of Philology and of Political Economy. Many Germans studied there, and the University has had considerable influence on the development of German thought. The students numbered 812, 405 of whom studied jurisprudence, 210 theology, 104 medicine, and 93 philosophy. Among the students there were two English princes, the Counts de Broglie and St. Simon, and Count Metternich. Humboldt remained only a year at Göttingen, leaving it in March, 1790. In after life he acknowledged that he owed to the University the best part of his education.

During the latter part of 1790 he travelled through England and France, and appears to have made most careful memoranda of everything that struck him in those countries. In the following year he entered the School of Mines, at Freiberg, which had been established in 1766, and was now enjoying considerable reputation on account of Werner's notoriety. He resided here only eight months, and was then appointed "Assessor *cum voto* in the Administrative Department of Mines and Smelting Works," which appointment was offered him "on account of the valuable knowledge, both theoretical and practical, possessed by him in mathematics, physics, natural history, chemistry, technology, the arts of mining and smelting, and the general routine of business."

Space will not permit us to do more than allude to the extremely interesting chapter (p. 161, vol. i.), on the state of society in Weimar and Jena, and the circle of cultivated men into whose midst Humboldt was introduced. Here we find anecdotes of Goethe and Schiller, and numerous extracts of letters from Humboldt and others.

In 1799 Humboldt began his greater travels, and to lay the foundation for his great "Cosmos." He visited Teneriffe, and then went to South America. The celebrated expedition to the Orinoco was commenced in 1800; he afterwards visited, in succession, Cuba, Quito, Mexico, and the United States, returning to Europe in August, 1804, after an absence of five years, during which he had travelled 40,000 miles in South America alone. The travels in Asiatic Russia were undertaken about twenty years later, at the request of the Russian Government.

Humboldt resided in Paris from 1808 to 1826. He originally went there on a diplomatic mission with Prince William of Prussia. He arrived at a time when the First Empire was at the height of its glory, and he entered at once into that brilliant circle of men of genius which had congregated in the capital of France. Here he published the results of his expedition to America in twenty folio and ten quarto volumes, the price of an unbound copy being £400. The work was not altogether a success; in the first place, the extravagant price prevented it from being generally purchased by scientific men; and in the second place, the numerous plates, which had caused the book to be so expensive, were not artistically good, and were quite unworthy of the good artists which then existed. While in Paris, Humboldt numbered among his friends at least two generations of scientific men; among them De Luc, Ingenhouz, Delambre, Laplace, Piçtet, Arago, Biot, Gay-Lussac, Thenard, Fourcroy, Vauquelin, Milne-Edwards, Jussieu, Haüy, Brongniart, Guizot, and Elie de Beaumont: a few of these men still remain active members of the Institute, while the very name of Fourcroy carries us back to the science of the last century. During his eighteen years of residence in Paris Humboldt was very

industrious ; he frequently read papers before the Institute, and published a number of valuable treatises on various subjects. The remainder of his life, which is regarded as the most important period of it, from 1827 to 1859, was passed in Berlin.

The change of residence was made for various reasons, notably because Humboldt was returning home, and felt that he could there better build up his great work, the "*Cosmos* ;" also because the king desired his presence. Prof. Dove, who writes this concluding portion of the biography, gives an interesting comparison of the Paris with the Berlin of forty years ago. The latter city appears to have been far behind the former, both in size and in everything else which tends to make a city great. The contrast must at first have been painful to Humboldt : he " comments in a spirit of bitterness and well-aimed satire upon the propensity of that ' audacious crew,' as Goethe calls the Berliners, to pull down everything claiming distinction when the first ebullition of enthusiasm has become exhausted." Rahel used to say—" In Berlin everything loses *prestige*, and is pulled down to the level of mediocrity, if not degraded to insignificance : were His Holiness himself to come to Berlin he would soon cease to be Pope, and become something quite ordinary, perhaps a horse-breaker." In fact, Humboldt had left a magnificent and wealthy city to settle down in a city vastly inferior, in intellect, wealth, and importance. However, he soon resumed his old activity, in spite of duties at court, which must have been sufficiently irksome. During the winter of 1827 and 1828 he gave a course of sixty-one lectures on Physical Geography, The first four of these, in which he gave a general description of Nature, appeared afterwards, in an extended form, as the first volume of "*Cosmos*." Other of the lectures formed the basis of succeeding volumes of the "*Cosmos*." When the book was printed, some years later, it was received with great enthusiasm, for it had been long expected, and it was known that Humboldt was the only man who could give to the world such vast generalisations as the subject demanded. " If it be true," says Dove, " that ' man wanders among the departed in the same form in which he leaves this earth,' then, at the name of Humboldt, the image of the author of "*Cosmos*" would rise before the mind as that of a venerable man, with head inclined and deeply-furrowed brow, bearing upon his shoulders, after the manner of Atlas, the burden of the universe—a strange creation, the full significance of which he only could estimate, since he alone had proved it by experience."

It is, we think, a matter of great regret that the translators have thought it wise to omit the third volume of this biography, which contains an account of Humboldt's scientific labours : the catalogue of his various works (appended to the second volume) has also been omitted. To many of us these will be felt as serious omissions. The work has been carefully translated, and

contains a great fund of interesting matter, not alone directly illustrating the life of Humboldt, but at that same time the character of the society in which he moved, and the times. As such it must be welcomed by all English readers of the "Cosmos."

Principles of Animal Mechanics. By the Rev. SAMUEL HAUGHTON, F.R.S., Fellow of Trinity College, Dublin, M.D. Dubl., D.C.L. Oxon. London: Longmans, Green, and Co. 1873. Pp. 495.

THIS great work cannot receive from us the notice which it deserves; the reviewer of it should be profoundly versed in the higher mathematics, and should be withal a skilled and practised anatomist. The Sciences of Geometry and Anatomy have not been hitherto sufficiently cultivated together. The anatomist who consults this work is staggered at the statement that attention is called to "the problem of the equilibrium of an elliptical muscular dome," and to the use made "of the hyperboloid of one sheet, of Ptolemy's Theorem, and of some curves of the third order;" and the geometer is puzzled by the difficulty of mastering, "*inter alia*," the course and attachments of the muscular fibres of the heart. There is no doubt, however, that the union of these two branches of science has produced, and will produce, results of the highest importance in relation to intellectual progress. Not only is a method pointed out for the investigation of some of the host of problems in Biology yet unsolved, but a new light is cast upon the question of medical education in the future. The University man need not cram his higher mathematics with the idea that if hereafter he joins the profession of medicine they must be forgotten to make way for anatomy and physiology, but he may be assured that his knowledge will serve him well in the special studies of his calling, and very probably in the scientific examinations which in the future he will have to pass. It will be a matter of surprise if Dr. Haughton's work fail to place its mark upon the examination papers of some universities. The Rev. Dr. Haughton is the Newton of the Muscular System, and no cultivated anatomist of this or future time can afford to pass by the study of his book.

The general argument of the work is to establish the validity of the principle of "least action in Nature"—the proposition that in the muscular system of animals there is a *perfect* adaptation of means to ends. The conclusion is irresistible that such adaptation is the result of design.

A large portion of the work is occupied by elaborate calculations of the statical and dynamical work done by man and by animals. The number and kinds of animals examined by the author are very great, and the labour of the investigation must have been immense. Some of the results are of great practical

importance—such are the calculations of the work done by muscles in rowing, climbing, and walking, by the human heart, and by the uterus in parturition. It appears that the oarsman who rows one knot in seven minutes performs a work the rate of which, while it lasts, equals six times that of a hard-worked labourer. The maximum hydrostatical force of the heart of man is nearly the same as that of the horse; the resistance to the circulation imposed by the capillaries varies much in different classes of animals—in the horse this resistance is only half of that which it is in the smaller animals. The daily work of both ventricles of the human heart is calculated to be 124·208 foot-tons; the work done by the heart per ounce per minute is 20·576 foot-pounds, whilst the work of the muscles engaged by the oarsman in a race is but 15·17 foot-pounds: in the one case the effort is continuous, night and day; in the other, the strain is for a short duration only. The greatest energy ever attained by a locomotive equalled only one-eighth part of the energy of the human heart. The calculation of the forces employed in parturition establishes points of high importance. “If ever,” the author says, “there was a muscular system produced to effect a specific object, the uterine muscle may be regarded as such.” This muscle possesses a force of 3·4 lbs., intended to overcome a maximum resistance of 3·1 lbs. The additional force of the abdominal muscles so raises this figure that on an emergency somewhat more than a quarter of a ton pressure can be brought to bear. The author’s words rather discourage the use of chloroform and other anæsthetics in labour; but here his conclusions are rather those of the abstract mathematician and physiologist than of the practical obstetrician, who recognises a very wide range, in various patients, of intensity of suffering and capacity of endurance.

The portion of the work devoted to the consideration of muscular types is also of very high interest. The calculations show the superiority in force of the tiger above the lion; the strength of the latter is about two-thirds of that of the former, and the power of the lioness about one-half that of the tiger. The investigation concerning the *Canidæ* embraces an elaborate examination of the celebrated greyhound, “Master McGrath.” As regards Man and the *Quadrumanæ*, some people will be glad to know that the difference between human kind and the gorilla is greater than the differences between the *Quadrumanæ* themselves. We quite agree with the author in thinking that over haste has been shown in generalising from purely anatomical data. “The skilful artisan can produce from the same number of wheels and pinions either a clock or a roasting-jack, fulfilling the very different functions of marking time and of roasting meat. An ignorant but intelligent savage, who was shown the interior of these machines, would come to the conclusion that they were very like each other, simply because he would consider only their

superficial resemblances, and would be unable to appreciate the purposes which the machines were intended to fulfil. In like manner, anatomists, from observation of apparent resemblances in the structure of organs, such as the brain (of the specific action of whose parts little or nothing is known), have sometimes, rashly, inferred a greater degree of affinity between various animals than there is any logical ground for admitting." (P. 423.)

We are disposed to take exception to certain of the physiological postulates expressed by the author. Speaking of the transmission of centripetal and centrifugal impressions to and from the encephalon, he says—"The time occupied by the sensitive nerves in conveying the impression to the *optic thalamus*, and by the motor nerve in re-conveying the order of the brain from the *corpus striatum*, is different in different persons." This implies the belief that the optic thalamus is the centre for sensation, and the corpus striatum the centre for motion. In face of the observations of Louget, Brown-Séquard, and especially of Vulpian, we consider that this view cannot now be held. Sensation is experienced by animals from whom not only the optic thalami but the whole of the cerebral lobes have been removed. Again, an animal whose corpora striata have been taken away is able to execute movements when irritated—movements which are not merely reflex.

A few errors of typography and spelling may be corrected with advantage in the next edition. A redundant letter frequently forces itself into the word "development," and a sentence reads that at night in London "the absence of *thoroughfare* in the streets enables the cabmen to drive *fats*."

The author says he brings his work to a close "with some regret," as it has afforded him many pleasant hours of thought and research. We hope that he has *not* brought his great and valuable researches to an end in the present work, but will continue to prosecute the task which, although he confesses it to be a pleasure to himself, is none the less a lasting boon to Science.

Geometric Turning. By H. S. SAVORY. London: Longmans and Co. 1873.

MR. SAVORY has here given to the turner, amateur or professional, a full description of a new geometric chuck invented by Mr. Plant. And it is interesting to learn what may be done with the instrument described in mechanical parlance as a "chuck." Supposing the reader conversant with the beautiful curves produced in geometric turning (for their beauty, although relying upon the greatest simplicity of order, is too complicate for description), it may be stated that if the chuck were arranged for all its loops it would produce 93,312, and at 100 revolutions a minute would take fifteen hours to complete the pattern.

"Such a combination, I suppose," says Mr. Savory, "no one has ever attempted; the general amount of time taken in cutting flues being from a quarter of a minute to five minutes." But further than this, the reader may gather an idea of the possible intricacy of the curves from the fact that a chuck could be constructed which, "if it made one revolution as the earth does in twenty-four hours, might go on for thousands and perhaps millions of years before it travelled again the same path; it would only be to make all the slides and radius self-acting, and the time when they would recur to the same position would be incalculable." Mr. Savory not only delights in the wonders of the appliance, but what he has to tell of his own progress towards perfection in its uses is rendered valuable by chronicle as well of failure as of success.

The Noaic Deluge: Its Probable Physical Effects and Present Evidences. By the Rev. S. LUCAS, F.G.S. London: Hodder and Stoughton. 1873.

Glimpses of the Future Life. With an Appendix on the Probable Law of Increase of the Human Race. By MUNGO PONTON, F.R.S.E. London: Longmans, Green, and Co. 1873.

THE Bible and Science or Science and the Bible has, not very recently perhaps, become a twofold object of investigation, and the emblem of certain sections of the religious and scientific community. Unfortunately, there is amongst writers on the joint subject a too general feeling of confidence in their strength and their comprehensiveness. Everyone feels that the subject is of exceeding difficulty, yet so interesting that it would be almost as difficult to maintain silence. Emphatically the relation of Religion and Science is not a question which a man of ordinary education is qualified to discuss. The intellect required is one trained at the same time to the observation of particulars and to the regard of generalities; and this without bias. Especially the expounder should be a Hebrew, a Greek, and perhaps an Oriental scholar. He, while an accurate and rigidly logical reasoner, must be capable of appreciating, yet of disregarding, the most delicate metaphor. Add to this the requirement of a knowledge of the natural sciences sufficient to rank the possessor as a scientific man; and is there any cause for wonder that our attempts at a conjoint judgment are so unsatisfactory?

But there is another method by which results may be attained more speedily; and it is that pursued by Mr. Lucas in his consideration "of the Noaic Deluge," as well as by Mr. Ponton in his "*Glimpses of the Future Life*." In the latter case we have a scientific man, who traces the authority of names into the original Hebrew, and who shows where science and logical argument may be brought to interpret the Bible. Mr. Lucas, on the con-

trary, finds that the Bible may, at least in its account of the deluge, be taken as throwing some light upon certain geological facts, while these facts may serve to confirm or corroborate biblical testimony. These views are undoubtedly those that will afford most definite results. They are based ultimately on the axiom that two truths cannot be more than apparently incompatible. And both our authors are men who have distinguished themselves in the investigation; Mr. Lucas is well known by his work, "The Biblical Antiquity of Man;" Mr. Ponton as the author of "The Beginning, its When and its How," noticed in these pages. Mr. Lucas states that he feels conscious that no difficulties besetting his own solution have been *designedly* overlooked or evaded; and that no *facts* requisite to a just and impartial view of the subject have been omitted or distorted. Nothing, in short, has been *assumed* but the truth of Scripture statement. Now this is as it should be. The scientific layman is as convinced of biblical truth as the biblical layman may be of scientific truth; obviously their only method of detecting error on either side is by *reductio ad absurdum*. But it is an open question as to which may be living in the glass-house, and it is better to continue to work, as our authors do, on the axiom of the negation of incompatibility of truths. Proceeding, then, on this common track, Mr. Lucas considers the deluge miraculous in its origin, and that it could not have been produced by any natural force. That it happened is shown by the evidence of present effect. That the "breaking up of the waters," the quiescent stage and the recession have been attended by well marked, although suppository, geological phenomena. Having conceded that the date of the Deluge admits, even upon Scriptural authority, of the utmost elasticity, it is possible that implements but not bones might be found pertaining to the antediluvian period, while the phenomena of "inundation mud" might be shown to be susceptible of explanation upon a diluvian theory. These are the main points of the work; the reader should exhaust it for himself.

With Mr. Ponton, in his "Glimpses of the Future," we are confessedly more at home, for he brings forward scientific reasoning in support of biblical statement. His treatment of Death and Hades as abstract ideas, the interpretation of "heavens" as meaning atmosphere, are especially characteristic of this author's liberal views. Passing, however, to the Appendix on the probable law of increase of the human race, we find it there said:—"The prevalence of law and order in all the proceedings of the Infinite Mind that rules the universe renders it probable that the multiplication of mankind on the earth may have been regulated by some law which a careful investigation may possibly discover." Having assumed that the present races of mankind have all sprung from the eight persons composing the family of Noah, it appears that twenty-seven reduplications from those

eight individuals would, with a slight addition, amount to the present population of the world. Considered that the limit to the population per square mile of land should be that of France (about 168), and that the thirtieth reduplication would bring up this average density throughout the globe, Mr. Ponton supposes that the limit reached, the number of the earth's inhabitants would thenceforward remain almost stationary. May, then, this reduplication have been governed by some law? The reasoning by which Mr. Ponton proceeds to trace out this law possesses the deepest interest. The results are carefully tabulated, and our readers will find the work well worthy of study.

Elements of Natural Philosophy. By Professors Sir W. THOMSON and G. P. TAIT. Part I. London: Macmillan and Co. 1873.

NATURAL Philosophy, as the good old English term runs, is too often so taught as to place the power of correlation as distant as possible. Indeed, the ordinary method works somewhat in this manner. Professors Sir William Thomson and G. P. Tait have chosen what appears certainly a more philosophic course; for, setting out with Newton's definition that "*mechanics* is the science of machines and the art of making them," and that the science which investigates the action of force is properly termed *dynamics*, we are led to the consideration of force acting in two ways (that is, so as to compel rest or prevent change of motion, and so as to produce or to change motion), as in Statics and Kinetics. It has been usual, in our text-books, to deal first with the laws of statics or the balancing of forces; but evidently the laws of kinetics (or rather of kinematics) present more obvious points to the student than do the laws of statics, which are necessarily subject to the limitation of equilibrium.

Yet this we conceive not the most important phase of progress exhibited in the treatment of the subject. Let the student have acquired his knowledge, let him have commenced his course of original research, there is still one higher step to be made, which, if not gained, will render his results of small worth. We refer to the means of becoming acquainted, by experiment, with the material universe and the laws which regulate it. "In general," to quote our authors, "the actions which we see ever taking place around us are *complex*, or due to the simultaneous action of many causes. When, as in astronomy, we endeavour to ascertain these causes by simply watching their effects, we *observe*; when, as in our laboratories, we interfere arbitrarily with the causes or circumstances of a phenomenon, we are said to *experiment*." To observation, for instances, we owe the data of astronomical, meteorological, and geological science; to experiment the deductions of spectrum analysis, electricity, and

the laws of falling bodies. "Mere observation of lightning and its effects could never have led to the discovery of their relation to the phenomena presented by rubbed amber. A modification of the course of Nature, such as the bringing down of atmospheric electricity into our laboratories, was necessary. Without experiment we could never even have learned the existence of terrestrial magnetism."

These are specimens of the exceedingly beautiful and unique illustrations of our authors. But these again are surpassed by the description of the laws by which the experimentalist should be controlled in the deduction of results. In all cases, to quote further, when a particular agent or cause is to be studied, experiments should be arranged in such a way as to lead, if possible, to results depending upon it alone. Or, if this cannot be done, they should be arranged so as to increase the effects due to the cause to be studied till these so far exceed the unavoidable concomitants, that the latter may be considered as only disturbing, not essentially modifying, the effects of the principal agent. Thus, in order to find the nature of the action of a galvanic current upon a magnetised needle, we may adopt either of these methods. For instance, we may neutralise the disturbing effects of the earth's magnetism on the needle by properly placing a magnetised bar in its neighbourhood. This is an instance of the first method. Or by increasing the strength of the current, or by coiling the wire many times about the needle, multiply the effects of the current so that those of the earth's magnetism may be negligible in comparison. In some cases, however, the latter mode of procedure is utterly deceptive—as, for instance, in the use of multiplying condensers for the detection of very small electromotive forces. In this case the friction between the parts of the condenser often produces more electricity than that which is to be measured, so that the true results cannot be deduced. We thus see that it is uncertain which of these methods may be preferable in any particular case; and, indeed, in discovery, he is the most likely to succeed who, not allowing himself to be disheartened by the non-success of one form of experiment, carefully varies his methods, and thus interrogates in every conceivable manner the subject of his investigations. A most important remark, due to Herschel, regards what are called *residual* phenomena. When, in an experiment, all known causes being allowed for, there remain certain unexplained effects (excessively slight it may be), these must be carefully investigated, and every conceivable variation of arrangement of apparatus, &c. tried; until, if possible, we manage so to exaggerate the residual phenomenon as to be able to detect its cause. It is here, perhaps, that in the present state of science we may most reasonably look for extensions of our knowledge; at all events we are warranted by the recent history of Natural Philosophy in so doing. Thus, to take only a very few instances,

to say nothing of the discovery of electricity and magnetism by the ancients, the peculiar smell observed in a room in which an electrical machine is kept in action, was long ago observed, but called the "smell of electricity," and thus left unexplained. The sagacity of Schönbein led to the discovery that this is due to the formation of ozone.

We cannot for want of space follow our authors through the consideration of the principle of repetition in experiment, agreement, and difference, the use of mathematical theories, and the evaluation of error by the method of least squares, all contained in one valuable chapter of a still more valuable volume. We have fulfilled our duty in presenting it to the notice of the teacher, the taught, and the reading public: to the teacher, because he will find in that which will silence the cry "there is no good text-book of Natural Philosophy;" to the student, because it shows how he should be taught or teach himself; to the reading public, because it will give a clear idea of the beauty and exactitude of the logical method in science.

Science Primers: Physical Geography. By ARCHIBALD GEIKIE, LL.D., F.R.S., Director of the Geological Survey of Scotland, and Murchison Professor of Geology and Mineralogy in the University of Edinburgh. London: Macmillan and Co. 1873.

THIS little work will be found of incalculable value to the elementary student. It will be alike interesting to the general reader, as giving a pleasing description of the phenomena of air, earth, and water. The author asks us to follow him in a country ramble, and read the book of Nature unfolded to us, to learn the relationship of the air we breathe and the earth upon which we live, and to watch with attentive eyes the changes which are continually taking place around us. The details are explained in a simple and comprehensive manner, and throughout the book a desire is evinced to impart knowledge which will be of practical value. It is illustrated by several woodcuts.

Physical Geography. By WILLIAM HUGHES, Professor of Geography in King's College, London, Author of "A Manual of Geography," &c. London: Longmans, Green, and Co. 1873.

THIS is a useful little school-book. It treats of the Earth's natural aspects, phenomena, and productions, in a simple and interesting manner. In the present day increased attention is given to the study of these natural phenomena, and this book will prove of material assistance to the elementary student. Teachers will do well to recommend it to their pupils.

On Coal at Home and Abroad, with Relation to Consumption, Demand, and Supply. By J. R. LEIFCHILD, M.A.

THIS is a re-publication of three articles contributed to the "Edinburgh Review," with an Appendix supplying information on the subject up to the latest date. The chief merit of this work is, that the large amount of statistical and general information which it affords on its subject is thus brought forward to the time of publication. The first essay, on "Consumption and Cost of Coal," is from the last April number of the "Edinburgh Review." Some of Mr. Leifchild's conclusions are discussed in our article on "The Limits of our Coal Supply." The next paper, "On the Coal-Fields of North America and Great Britain," contains a large amount of valuable statistical and geological information; and the same praise is due to the third essay, on "Fatal Accidents in Coal-Mines," and to the Appendix. Many of the facts here stated are but little known to general, or even to scientific, readers that have not lived in black-country districts. For example, during ten years, the deaths from fire-damp explosions—commonly regarded as the most fatal of the dangers of coal-mining—were only about one-fifth of the total fatal accidents. Those from the falls of the roof and coal—of which we commonly hear so little—reached to about two-fifths. Shaft accidents less than one-fifth, and miscellaneous causes and above-ground rather more than one-fifth. We cannot venture upon any further reference to the closely-packed yet readably-connected facts of this small volume, which we strongly recommend to the perusal of all who are interested in the subject.

PROGRESS IN SCIENCE.

MINING.

FROM the evidence recently given by the several coal inspectors before Mr. Mundella's committee for inquiring into the present state of our coal trade, under the presidency of Mr. Ayrton, we are enabled to glean figures which represent the actual production of coal in Great Britain during the year 1872. The following statistics, showing the output of last year, are of much interest for comparison with the returns of the previous year:—

	Tons.
South Durham	17,395,000
Northumberland and Durham	13,000,600
Yorkshire	14,576,000
Derbyshire	10,660,000
Lancashire and North Wales	18,363,236
North Staffordshire and Worcestershire	6,327,188
South Staffordshire	10,550,000
Gloucestershire and Somersetshire	7,000,000
South Wales	10,131,725
Scotland	15,383,609
Total	123,386,758

These figures show that, so far from the rise in prices and the disturbed state of the labour market having diminished the production of coal in 1872—as might fairly have been supposed—we actually raised during that year several millions of tons more coal than in 1871.

The progress of some trial-sinkings for coal, in the neighbourhood of Cannock Chase, deserves to be chronicled for the scientific interest attaching to these explorations, and the light which they promise to throw upon the relations between the coal-fields of Staffordshire and Shropshire. At Fair Oak, a little north-west of Cannock Chase, a boring has proved the existence of coal-measures beneath the Bunter conglomerates, without the intervention of any Permian rocks. At Huntington, due west of Cannock Chase, a hole is being put down with a diamond-mounted borer, but, at the time we write, coal has not been reached.

The well known trial-sinking at Sandwell Park Colliery is progressing favourably. A second seam of coal has been reached at a depth of 232 yards. This seam is about 11 inches in thickness, and rests on a true fire-clay floor.

In the South of England, the Sub-Wealden boring continues to make way, though not so rapidly as might be wished. A fine bed of gypsum, between 50 and 60 feet thick, has been passed through, and promises to become of much economic value. The specimens which we have seen show that the mineral is a beautifully white fine-grained gypsum, which might evidently be worked with great profit. The bed occurs in the Poundsford series, formerly classed with the lower beds of the Weald, but now believed to be of Purbeck age.

An admirable geological description of the coal-bearing oolites of Brora, in Sutherlandshire, will be found in Mr. J. W. Judd's memoir "On the Secondary Rocks of Eastern Scotland, published in the May number of the "Journal of the Geological Society of London." It is these oolitic coals that have lately attracted so much attention; the Duke of Sutherland having, with characteristic energy, authorised a thorough exploration of the old Brora mines, with the view of again testing their coal-producing capabilities.

A new safety-lamp, constructed on an ingenious principle, has been patented by Mr. Landau. The air required for combustion is contained in a chamber

in the lamp itself, so that it is completely independent of the external atmosphere. A chamber of a capacity of not more than 36 cubic inches, is found sufficiently large to contain a supply of air for twelve hours' use. The products of combustion are carried off and condensed by a bent or coiled tube fixed at the top of the lamp. The patentee recommends that the air should be compressed at the mouth of the pit, and that the condensation pipes should be carried to the top of the shaft so as to avoid the retention of hot gases and vapours in the mine.

A form of rock-drill, known as the Power Jumper, has been patented by Messrs. Brydon, Davidson, and Warrington. This drill is said to be recommended by its simplicity, lightness, and small size; and may be worked with a pressure of steam or compressed air of only 30 or 40 lbs. to the square inch.

Mr. Henry S. Poole, the new Inspector of Mines for Nova Scotia, has presented to the Commissioner of Public Works and Mines an excellent report on "Mining in the Province." This report gives a very encouraging account of the present position of coal-mining.

An account of the mineral resources of India by so competent a geologist, and one so well acquainted with the country, as Mr. W. T. Blanford, necessarily commands attention. Mr. Blanford's paper, recently read before the Society of Arts, does not, however, give a very brilliant view of the mineral wealth of our Indian possessions. The ores of copper, lead, and silver, and the deposits containing gold and diamonds, are really of but small value. Tin-ore, on the contrary, occurs in valuable deposits in the Tenasserim provinces, and salt-mines of great importance are worked in the Punjab. Coal is abundant within a certain area, but the quality is inferior. The deposits of iron ore, however, are, according to Mr. Blanford, destined to be the chief source of India's mineral wealth in the future: these ores, though hitherto but little worked, are extremely plentiful, and in some cases are of very high quality.

A recent meeting of the South Midland Institute of Mining Engineers, at Wolverhampton, a paper on "Colliery Winding Engines" was read by Mr. S. Watkins. After discussing the most important requirements of a colliery engine, he advocated the use of the direct-acting horizontal engine, with link-motion and reversing excentrics for valve-gearing.

Among the papers read at a recent meeting of the South Wales Institute of Mining Engineers, we may mention one, by Mr. J. Snape, on the "Use of Compressed Air Underground for Winding and Pumping."

The Rev. H. Sandford has communicated to the South Staffordshire and East Worcestershire Institute of Mining Engineers a paper on "Mines' Schools in Germany," in which he describes the method of instruction pursued in the schools at Saarbrück and Siegen, and compares it with the education given in this country.

METALLURGY.

During the past quarter the Iron and Steel Institute has held its Annual General Meeting. Mr. Bessemer, the retiring President, has been succeeded by Mr. I. Lowthian Bell, who took occasion, in his presidential address, to lay before the Institute a masterly review of the present position of the iron and steel manufactures of this country. It is pleasing to remark that Mr. Bessemer has liberally placed in the hands of the Council a sum of money for the purpose of founding a gold medal to be awarded annually for the promotion of metallurgical science, either by original research or by literary work.

Among the communications presented to the Institute at this meeting, we may call especial attention to Dr. C. W. Siemens's paper on the "Manufacture of Iron and Steel by the Direct Process." The iron and steel produced by this direct process are said to be of very high quality, and this in spite of the presence of prejudicial ingredients in the raw materials.

At the same meeting of the Iron and Steel Institute, Mr. T. R. Crampton read a paper on the "Combustion of Powdered Fuel in Revolving Furnaces, and its application to Heating and Puddling Furnaces."

The conditions under which highly silicated pig-iron is produced in the blast-furnace have been studied by M. Samson Jordan, who has lately communicated the results of his researches to the French Academy of Sciences. His observations were made at the Heerd Iron-works, near Dusseldorf. He concludes that the furnace should be worked slowly at a high temperature, and that the charge should be rich in silica and alumina.

Although scheme after scheme has been proposed for the utilisation of blast-furnace slags, which are so terrible a burden to the ironmaster, it cannot be said that any of these schemes have hitherto been entirely successful. Mr. Wood, of the Tees Iron-works, at Middlesbro', has, however, recently invented a machine for crushing blast-furnace slag, until it is reduced to the consistency of sand. Mixed with 8 or 10 per cent of quicklime, this sand when compressed is said to make excellent concrete bricks, which can be used for building without requiring to be burnt. Moreover, it is suggested that the slag-sand may be advantageously used as a manure.

Bricks of slag are also now made by Mr. Woodward, of Darlington. He merely runs the cinder from the furnaces into moulds, and then subjects the bricks to a process of annealing.

It is worth recording that the fusion of platinum in a furnace of powerful draught has been effected by M. Violette. Fifty grammes of platinum, partly in fragments and partly in the state of sponge, were placed in a Hessian crucible lined with plumbago, and subjected for one hour to the heat of the furnace. A perfectly-fused button of platinum, of the same weight as that of the metal introduced, was found at the bottom of the crucible.

In consequence of the great advance in the price of nickel, a correspondent of "The Times," pretty generally known to be Dr. Percy, has called attention to the fact that a substitute for nickel-silver has long been known, though not manufactured. By substituting manganese for nickel, the writer found that an alloy might be obtained, having all the characters of German silver; but though this alloy was known more than twenty years ago its manufacture has hitherto, for commercial reasons, been suppressed. The present price of nickel—consequent upon the great demand for this metal for purposes of coinage, as well as for nickel-silver and for electro nickel-plating—may lead to the manufacture of this manganese alloy in the place of ordinary German silver.

As the contemplated reform in the German coinage is expected to absorb an enormous quantity of nickel within the next two years, it is worth noting that some authorities have suggested that other metals, instead of nickel-alloys, might advantageously be used for the new coins. Dr. Clemens Winkler strongly advocates the employment of pure aluminium for small pieces, and points to the properties of this metal as precisely those which adapt it in an eminent degree for the purposes of coinage.

MINERALOGY,

Every student of mineralogy is familiar with the fine icositetrahedral, or 24-faced, crystals of Leucite, which occur embedded in the lavas of Vesuvius, and were formerly called "white garnets." These crystals are always regarded as characteristic forms of the cubic system—so characteristic, indeed, that the icositetrahedron has been called, in Haidinger's nomenclature, the *Leucitoid*. Prof. Vom Rath, of Bonn, has, however, been led to study these crystals in a new light, and the results of this study show that the mineral must be transferred from the cubic to the pyramidal system.* By observing the direction of certain striæ on the trapezoidal faces of some of these crystals, he found that they were not mere superficial markings, but were really the

* LEONHART and GEINITZ's "Neues Jahrbuch für Mineralogie, U.S.W.," 1873, Heft II., page 113.

edges of twin lamellæ. He has since shown that the common icositetrahedron of leucite is really a combination of the 16 faces of the ditetragonal octahedron with the 8 faces of the primitive octahedron—four of these being above and four below the faces of the ditetragonal pyramid. Leucite is thus brought within the group of these minerals so characteristic of Vesuvius, which crystallise in the pyramidal system—a group which includes zircon, humboldtite, meionite, vesuvian, and sarcolite.

It has long been known that diamonds of some size occur in the gold fields of California, and Prof. B. Silliman had suggested that they might be found in the heavy sands from the sluices of the hydraulic washings. This suggestion has lately been verified.* A parcel of sand, taken from the tailings in one of the sluices of the Spring Valley Mining Claim, Cherokee, has been subjected to a searching microscopic examination by Prof. Silliman. This examination has shown that the sands abound in beautiful colourless crystals of zircon, associated with crystals of topaz, fragments of quartz, and granules of chromite and titanite iron ore. But in addition to these minerals, there are a few small masses of a very highly refractive substance, believed from its chemical and physical characters to be true diamond.

Bauxite—the mineral which has long been employed in the manufacture of aluminium—is used by Dr. C. W. Siemens for lining the rotary furnaces in which he produces iron and steel direct from the ore. According to Mr. Riley, large supplies of this mineral are likely to be yielded by the deposits of aluminous iron ores in the north-east of Ireland.

Some time ago we had occasion to mention the discovery of some new minerals containing uranium at the Weisser Hirsch Mine, near Schneeberg, in Saxony. Dr. Clemens Winkler has published, in a recent number of the "Journal für Praktische Chemie," the results of his analyses of these minerals.

Some confusion has arisen between the two species *amblygonite* and *montebrasite*, but the distinction has been clearly established by Des Cloiseaux. In 1862, a mineral was found at Hebron, in Maine, U.S., and referred to the species *amblygonite*; in 1870 a mineral was found at Montebras, in France, and named *Montebrasite*. Now it has since turned out that the original mineral from Montebras is merely *amblygonite*, but a second species has been found in this locality to which the name of *Montebrasite* has been transferred; and it is now proved that the so-called *amblygonite* from Hebron is really this true *Montebrasite*. The matter therefore stands thus: two minerals are found at Montebras—one called *montebrasite* and the other *amblygonite*; the former is also found at Hebron in the United States, and the latter occurs also at Penig, in Saxony. *Montebrasite* contains lithia but no soda, and also contains a notable proportion of water; *amblygonite* contains both soda and lithia, but no water.

Axinite is one of those doubly-oblique minerals whose crystalline forms, so difficult to the student, have been carefully worked out by several crystallographers. Herr Hessenberg has lately examined the axinite from Botallack, in Cornwall, and has discovered two forms new to this species. His paper is well worth thoughtful reading, for the sake of his sensible remarks on the use and abuse of crystallographic symbols.

Some observations on the celestine, or sulphate of strontia, of Rüdersdorf, and of Mokattam near Cairo, have been published by Herr Arzruni. He has also analysed specimens of celestine from several typical localities with the view of observing the effect of isomorphous replacements on the crystalline form of the species.

The new species *Pucherite*—a vanadate of bismuth, from Schneeberg, in Saxony—has formed the subject of a careful crystallographic study by Herr Websky. It appears that the forms of *pucherite* admit of comparison with those of *brookite*.

Fluor-spar must be reckoned among those crystallised compounds, which, though abundant enough in nature, have not hitherto been artificially prepared

* "Chemical News," May 2nd, 1873, p. 212.

by the chemist. It is therefore worth noting that quite recently Messrs. T. Scheerer and E. Drechsel have succeeded in obtaining crystallised fluoride of calcium.*

We are glad to observe that the excellent series of crystallographic "nets," constructed and published some years ago by Mr. J. B. Jordan, has been lately reproduced at a low price by Mr. Murby, of Bouverie Street. No better means can be recommended to the student of crystallography, in mastering the elements of this confessedly difficult subject, than the construction of a set of pasteboard models from nets or outlines such as are furnished in these sheets.

ENGINEERING—CIVIL AND MECHANICAL.

Water-Lifting Apparatus.—Prall's water-lifting apparatus, designed for raising water into the tender tanks of locomotives, may be considered as an offshoot from the Westinghouse air-break, and by its use the necessity of providing pumping machinery at stations may in a great measure be obviated. The nature of this apparatus may be thus briefly explained:—At or near the bottom of a well is placed a closed box, with a valve on its under side, by means of which it is kept full by the pressure of the water in the well. From the top of this box are two pipes rising up above the ground; at the upper end of the one pipe, which extends to near the bottom of the box, is a branch for conveying water to the tender; whilst the other, which merely enters the box at its upper side, is fitted at the other end with a branch, which, by means of a length of flexible tubing and a union-joint, can be put in communication with a pipe on the locomotive connected to the compressed air-reservoir of the break. This connection being made, the engine-driver can merely, by turning a cock, allow the compressed air to flow from the reservoir to the submerged tank, when it will, by pressing on the surface of the water in the latter, force this water up the rising main, and enable it to be discharged into the tender tank. On a sufficient supply of water having been raised, the cock is shut, the joint with the air-cylinder disconnected, and the compressed air from the submerged tank escaping allows the bottom valve to open, and the tank becomes again charged ready for another operation.

Retaining Walls.—In a paper read before the American Society of Engineers, by Mr. Casimir Constable, it was stated that a retaining wall is stable when the amount of its weight about the point of rotation exceeds the amount of a certain triangular prism of material back of the wall, about the same point—the intersection of the line of rupture of the wall, and the resultant thrust of the prism. Many formulæ and tables for retaining walls are presented for use, without a factor of safety, since walls proportioned therewith—well built and carefully back-filled—have been permanent. Experiments made on a small scale, in which the theoretic conditions were more nearly fulfilled than in practice, show that such walls are stable, and point out the reason why. The problem having been thus solved, a factor of safety may be introduced in the formulæ, which will allow for shocks, irregular workmanship, and uncertain material. The problem was then considered under these several heads:—the angle of rupture, the height of the prism of rupture, and the direction and point of application of the pressure of the prism. It was shown that the prism of greatest pressure is given by the plane which bisects the angle of repose, and that—

$$P = \frac{1}{2} w_1 h^2 \tan^2 \frac{i}{2},$$

in which P = the horizontal force which sustains the prism, w the weight per cubic foot, h the height, and i the angle of the prism.

Pneumatic Foundations.—A paper on this subject was read before the American Society of Civil Engineers, at New York, on the 19th of February last, by General W. Sovy Smith. From that paper it appears that the first two bridges on pneumatic pile foundations, erected in the United States, were—

* "Journal für Praktische Chemie," 1873, No. 2, p. 63.

one over the Santee River, on the North-Eastern Railroad, built in 1855; and the other over the Great Pedee River, on the Wilmington, Columbia, and Augusta Railroad, built in 1857. The air-lock used in sinking these piles was invented by Alexander Holstrom. It was a cast-iron cylinder, 6 feet in diameter and 4 feet high, closed at top and bottom by cast-iron plates, through which were man-holes, opening downward for entrance, and bull's-eyes of glass for light. Two goose-neck pipes passed through the sides and bottom—one for introduction of air, and the other for the discharge of water, when it would not escape through the material underneath the pile. A windlass was attached for raising the earth within the pile, all of which was removed by hand. There were four air-pumps set in a single frame. Construction of the pneumatic pile piers for a bridge over the Savannah River, on the Charlestown and Savannah Railroad was begun in the fall of 1859. The air-lock used was 6 feet instead of 4 feet high, and the cylinders were of wrought- instead of cast-iron. In order to overcome certain defects which made themselves apparent, an air-lock was made of less diameter than the pile, so that an annular space was left between the two, in the plate covering the top of the latter, into which bull's-eyes were introduced. Through the side of the air-lock was a pipe or trap, inclined at an angle to discharge readily any material put into it, and arranged for closing at either end; the outer end being closed, the trap was filled with material, the inner end was then closed, the compressed air thus cut off from the air-lock liberated, and the outer end opened, when the material would pass out. By reversing the process the trap was made ready to receive material again. By this means nearly twice as much work was done in the same time as with the Holstrom air-lock. It was soon found that the sandy material through which these piles were sunk could be raised by the escaping compressed air through a discharge-pipe, and delivered outside in a continuous stream; for this the mouth of a flexible tube, fitted to the lower end of a fixed pipe, was thrust into the wet sand, and moved from place to place as the material disappeared. The ratio of work done to that with the whole air-lock, which before was as 28 to 10, now became as 28 to 1.

The Rigi Railway.—On the 29th of April last Dr. William Pole, F.R.S., read a paper, before the Institution of Civil Engineers, on the Rigi Railway. The object of this railway is to convey passengers to the top of the Rigi, there being no carriage-road thither, the only means of ascent having hitherto been either by walking or by horses, or by *chaises à porteurs*. The summit of this mountain is 4500 feet above the plain, and an unusually steep gradient of about 1 in 4 was necessary. The line commences at Vitznau, on the Lake of Lucerne, and is about 4 miles long. The works are mostly formed by cutting and benching on the rocky slope of the mountain; there is one short tunnel, and but one iron bridge over a ravine. The gauge is 4 feet 8½ inches, and the rails are of the Vignoles shape, weighing 34 lbs. to the yard. The ascent is made by means of a rack and pinion arrangement, similar to that proposed and constructed by Mr. Blenkinsop in 1811. The rack is placed midway between the rails, and is formed of two wrought-iron cheek-plates, having wrought-iron teeth inserted between them and rivetted on each side. The pitch of the teeth is nearly 4 inches. The locomotive weighs about 12 tons, and is supported on four wheels. The boiler is vertical, and its axis is inclined to the base line, so as to be nearly upright when running on the steep gradient. The crank-shaft is worked by gearing on the main axle, on which the cog-wheel is placed. The speed on the incline does not exceed 3 or 4 miles per hour, either up or down: the danger of getting off the rails is met by clips fastened to the vehicles, which pass under the rack bar, and would, if the wheels should run off, prevent the carriages from getting away. Clip-brakes are provided which embrace drums on the cogged wheel-axles, so that when these clips are tightened the cogs are held fast in the rack, and thus support the weight of the vehicle, preventing it from running down the incline.

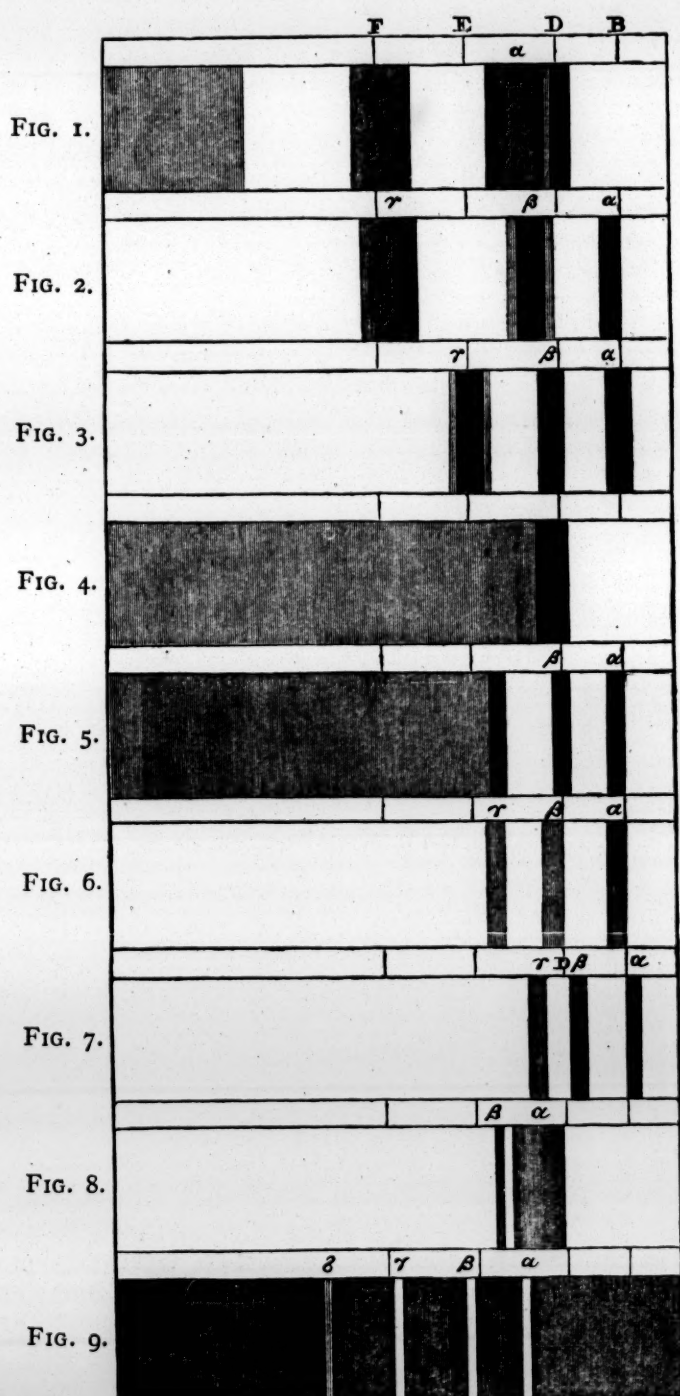
Dynamometers.—A paper has recently been read, before the Franklin Institute, on the Francis Dynamometer, by Mr. Samuel Webber. The principle of the dynamometer is that of obtaining the "horse-power," on weight moved 1 foot per second, by suspending that weight to the end of a steelyard, which,

were it not thus confined, would be free to rotate, and which would describe a circle of which its length is the radius. The first shaft, passed directly through the axis of the steelyard, has fast on it, at one end, the driven pulley and a bevel gear, which forms one side of a compound or box gear. The bevel on the opposite side and the delivering gear are fast on a sleeve or collar, which is caused to revolve in an opposite direction to the shaft by the two intermediate bevels, which complete the compound, and which, being driven by the first gear, rotate freely around the steelyard, when no power is being transmitted, with the exception of such action as is due to the friction of the shaft and gears, which friction is ascertained and deducted in making a test of power. The weight used on the original machine was 1 lb., and the length of the steelyard such as to move the weight at its extremity 10 feet in one revolution, or 1000 feet in 100 revolutions; therefore 1 lb. moved 1000 feet represented 1000 lbs. moved 1 foot. In the improved instrument the steelyard is made the base of calculation, and is graduated in inches and tenths, each inch representing 100 lbs. Starting at $6\frac{1}{4}$ inches from the centre to clear the frame, the graduation is carried out 20 inches or to 2000 lbs., and the weight obtained as follows:—The extreme length is now $26\frac{1}{4}$ inches, thus being the radius of a circle of 53 inches diameter, or 166.504 inches circumference. This is 13.8753 feet described in one revolution, and the weight, to correspond to 1 lb. moved 10 feet, is found to be 0.7207 lb. Now this weight is only one-half of that required, for on the steelyard the action is that of supporting a weight supported at one end, and the weight is therefore doubled, making it 1.4414 lbs., or 1 lb. $7\frac{1}{8}$ ozs. to represent 1000 lbs. raised 1 foot in a second. The poise or slide weight is obtained by a different calculation, as it is to represent 100 lbs. for every inch it is moved, and as a circle of 1 inch radius is 6.2832 in circumference, 100 times that circle is 628.32 inches, or 52.36 feet; and the weight to correspond with 1 lb. moved 100 feet, or 100 lbs. moved 1 foot, is found to be 1.9098 lbs., which, being doubled as before, gives 3.8197 lbs., or 3 lbs. $13\frac{3}{8}$ ozs. nearly for the movable weight. A worm gear on the second shaft drives the clock by a pinion of 100 teeth, and at every 100 revolutions rings a bell. The practical operation of the dynamometer is this:—Having carefully levelled it and secured it to the floor in the proper line of motion, a belt is brought from the driving pulley on the shaft to the first pulley on the dynamometer, and one led from the second pulley on the dynamometer to the main pulley of the machine to be weighed, and the whole put in motion. The action of the bevel gears immediately raises the steelyard, which is then weighted till it remains motionless in a horizontal position. This weight is noted, and also the number of seconds consumed in making 100 revolutions. The belt leading to the machine is then thrown off, and the weight required to balance the dynamometer in motion also noted and deducted from the total weight. The weight thus obtained is divided by the number of seconds consumed, and the result is the number of pounds raised 1 foot in 1 second.

LIGHT.

Mr. Charles Horner has contributed a paper to the "Chemical News" on the "Spectra of some Cobalt Compounds in Blowpipe Chemistry." A spectroscopy of low dispersive power is essential for seeing distinctly the bands due to these compounds; and since the accurate position of the absorption-bands had to be determined, the author had recourse to the micro-spectroscope, which enabled him to measure them with precision, although a small hand spectroscopy, like Mr. Browning's "Miniature" instrument, is very convenient, especially for examining the spectra of hot beads. Mr. Sorby's interference-plate was used as a scale of reference, whilst Mr. Browning's bright point micrometer served as an indicator. When cobalt oxide is added to boric acid, and strongly fused for two or three minutes in the inner flame, using gas as a source of heat, the cold bead possesses a dull blue colour, and is almost opaque. However, by using a powerful light it gives a spectrum of three very faint bands, nearly in the same position as shown in Fig. 2; if, now, 1 per cent of sodium carbonate be

taken up, and the bead treated as before, when cold, the colour is a murky reddish purple, and the spectrum no longer giving the band in the red, but two obscure absorption-bands, very close together, and a slight shading at F, as



shown in Fig. 1. Upon adding 4 per cent of soda the bead becomes quite clear and paler, showing the same spectrum, but while *hot* showing the band α , as in Fig. 2. A further addition of 10 per cent of sodium carbonate causes

the bead to remain a dark purple when cold, and exhibiting the complete spectrum of Fig. 2. When 25 per cent has been added a blue bead results, and the spectrum in Fig. 2 changes; the band marked β is perceptibly lowered, overlapping D, as in Fig. 3, but the band γ remains as in Fig. 2. If 5 per cent more is taken up, the three absorption-bands are like those drawn in Fig. 3, which represents cobalt dissolved in borax. The bead is now very dark, and requires pressing, whilst hot, between the points of the forceps, to render it sufficiently diaphanous. In these experiments it is necessary the amount of cobalt should be known when added to the weighed boric acid bead, since the determination of the alkali is affected by the quantity of oxide present; e.g., if enough cobalt has not been dissolved, it may require 17½ per cent of sodium carbonate to render the band visible in the red of Fig. 2. Fig. 4 represents the spectrum of a salt of magnesia when moistened with a solution of cobalt. Fig. 5 is the spectrum of the indigo-blue compound of calcium oxide when treated with cobalt. Fig. 6 is the interesting spectrum of the bright blue compound of alumina. The beautiful green compound of oxide of zinc, which is occasionally used as a pigment, and known as Rinman's green, gives the spectrum portrayed in Fig. 7. When a thin soda bead is formed with a mere fragment of boric acid, and fused along with a little cobalt, in the outer flame, the bead while hot is of a deep orange-brown colour, turning nearly black and opaque on cooling, but before becoming quite cold rapidly crystallises and turns green. By transmitted light the whole of the blue is cut off and part of the red, while a narrow band is visible at the yellow end of the green. If the bead, however, be submitted to the action of the inner flame, it turns a pale blue while hot, and crystallises on cooling to a pale pink by transmitted light, assumes a lavender tint by reflected light. This unique spectrum of the pink bead is depicted in Fig. 8; and Fig. 9 represents the flame spectrum of boric acid, consisting of four bright bands.

Mr. George J. Warner, F.C.S., calls attention to the peculiarly sensitive character of Wallace's gas-burner. It consists of a hemispherical chamber, into which the gas is introduced through a cone fixed horizontally at a tangent, the position of the jet with regard to the cone being so adjusted that the quantity of air injected by the velocity of the gas at all ordinary pressures is always the proportion required for its perfect combustion. The upper part of the interior of the chamber is lined with wire gauze, and from it issue one or more tubes, at which the gas is burned. At ordinary pressures the flame is of the colour of a Bunsen burner, but with a central cone, clearly defined, of pure green, whether it be turned high or low. But if the gas be reduced below the ordinary pressure on the main, the flame becomes white-tipped, and there is no longer perfect combustion, as in a defective Bunsen. We then find that the flame is sensitive to sound, to all sound in fact, but to high notes particularly.

MICROSCOPY.—Mr. H. C. Sorby has obtained from *Aphides* an orange-coloured fluid, which he names aphidiholeine, giving a very remarkable



spectrum. A narrow band in the orange, having the D line in its centre, another close to the upper edge of the first band of nitrate of didymium, a third a little above E, the general absorption towards the blue commences about midway between b and F, and becomes stronger near the fifth band of nitrate of didymium. The band in the orange is a singular and unexpected phenomenon in a fluid of the same colour.

Mr. E. Ray Lankester, describes the spectrum of *Stentorin*, the colouring matter of *Stentor carulus*.* It has two bands, the stronger in the red on the lower side of the C line; its centre is nearer the blue than the red band of fresh chlorophyll. The second band in the green lies somewhat to the blue side of the lower band of fresh blood. Light which has been passed through the thickness of only a single *Stentor* (which cannot be more than a few thousandths of an inch) is sufficiently affected to show the bands quite sharply. This affords an instance of the value of the micro-spectroscope in cases where only a small amount of coloured material is procurable.

In a paper on a new species of *Callidina*, read before the Royal Microscopical Society,† Mr. H. Davis, F.R.M.S., gives the result of his experiments on the desiccation of this and other rotifers. He has, in common with Pouchet and other observers, arrived at the conclusion that rotifers when completely dried do not revive upon being placed in water. Those which have recovered, and some have done so after gradually heating to 200° F. in an oven, and being kept for a week under an exhausted receiver with sulphuric acid, have been protected, according to Mr. Davis's observations, by a gelatinous secretion which dries over them into a hard thin shell, and effectually secures them from the most complete desiccation the chemist can effect. That such a coating is an effectual protection was demonstrated by the production at the meeting of some grapes coated with gelatine, which had been with sulphuric acid in an exhausted receiver for seven days and nights, and were still perfectly fresh and juicy, while some from the same bunch put by in a cupboard without protection were shrivelled and mouldy.

The lens ruled in squares‡ by Mr. Ackland for the purpose of making drawings of objects under the microscope has, upon trial, proved successful, the definition being very little affected by it. The markings of the scale of *Lepidocyrtus curvicolis* ("the test Podura") were very well seen under an eighth of Powell and Lealand's new make, magnifying with the eye-piece employed about 800 diameters, scarcely any mischief was done excepting the production of a little colour, the "I markings" were clear enough to permit of a good drawing being made. A convenient size for the squares is 0.05 inch. The drawings are made on ruled paper, several sizes of which, under the name of "sectional paper," are manufactured by Messrs. Letts. Although originally intended for the use of architects, for enlarging and reducing it will be found equally available for microscopical purposes.

The well-known large microscope stand of Mr. Thomas Ross has been remodelled and improved by Mr. F. H. Wenham. The base consists of a single casting, the claws of which are well spread, and give a very firm support to the movable portions of the instrument. The chief variation from the former construction consists in the adoption of the "*Jackson Model*," so strongly advocated by Dr. Carpenter,§ and respecting the rigidity of which there cannot be the least doubt. This is so adapted as not to interfere with the elaborate stage mechanism, which works as freely as in the old form. The "*dove-tail groove*" in the limb is supplemented in its action by a broad flange on the bar carrying the body, which works in close contact with a corresponding plate on the limb, and prevents any chance of a rocking motion taking place. The fine adjustment, as will be seen by the woodcut, is placed in an extremely convenient position, and can easily be reached from either side without the hand being removed from the milled head working the rack motion. The stage and sub-stage arrangements are the same as those in the older form, and need no especial mention. The stand, as now improved, is to be particularly recommended for its great strength and consequent capability of standing hard wear, a quality of considerable importance to the working microscopist. The stiffness of its framing will also recommend it to those who are compelled to carry on high power observations in unquiet situations

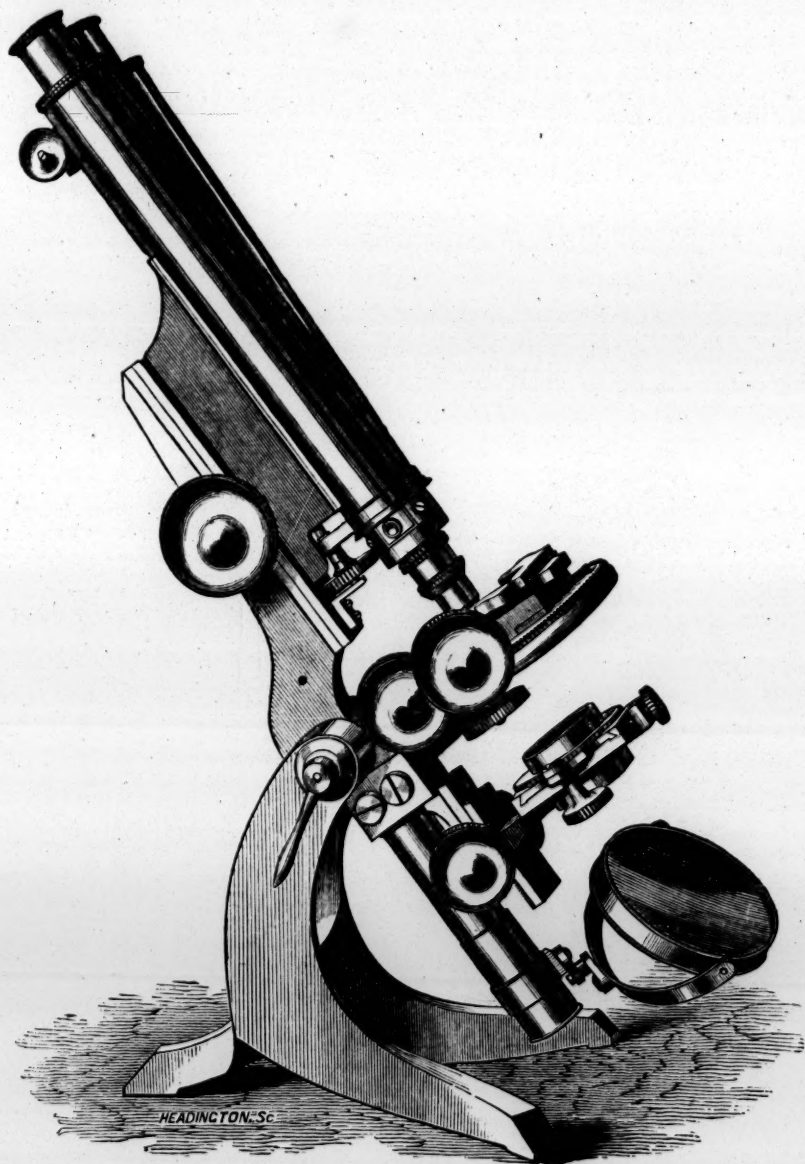
* Quart. Journ. Micros. Soc., April, 1873, p. 140.

† Month. Micros. Journ., vol. ix., p. 201.

‡ Quart. Journ. Science, p. 277.

§ Monthly Micros. Journ., vol. iii., p. 183.

and to whom the tremor of the old model was very annoying. The old pattern has been kept in favour solely by the great care taken in its construction by our leading makers, the slightest defect in workmanship being in this form very apparent, and causing a fatal amount of unsteadiness. It affords a remarkable instance of constructive skill overcoming in a great degree the



defects of an originally faulty design. That this form should have been ultimately adopted by the late Andrew Ross is very remarkable, as his older microscopes, as well as those of Mr. Powell, had the body supported by a considerable portion of its length upon a rigid limb.*

Dr. J. G. Richardson communicates to the "*Philadelphia Medical Times*" some account of the properties of acetate of potash in temporarily preserving tissues during transmission for examination. The process has been principally

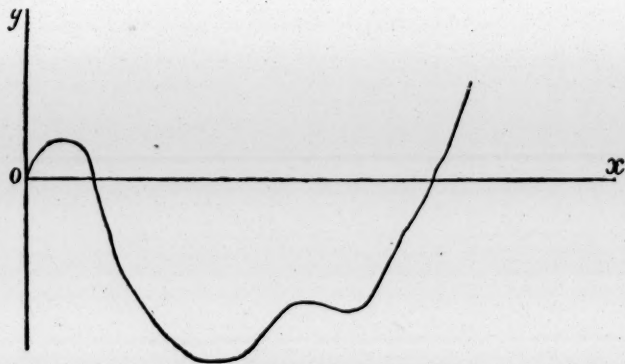
* Penny Cyclopædia, vol. xv., p. 187; article "Microscope," by ANDREW ROSS. A fine specimen of Powell's old construction is in the collection of instruments of the Royal Microscopical Society.

applied to urinary deposits and other pathological specimens. The former, placed in small bottles, arrived in perfectly good condition after a journey of a week in hot weather. Fragments of tumours and other diseased tissues were soaked in a saturated solution for forty-eight hours, until thoroughly imbued with the fluid. They were then pressed, to remove superfluous moisture, and tied up in thin sheet india-rubber or oil silk, and so transmitted by post.

HEAT.

An experiment lately made by Mr. Spence, of Manchester, seems to prove that under certain conditions the diamond is combustible at a much lower temperature than has been hitherto supposed. A South African diamond of the size of a small pea, coated with refractory clay, was placed in a crucible with a mixture of soda and hydrate of lime, and then heated in a muffle for three days and three nights. On opening the mass, it was found that the diamond had entirely disappeared, although the heat had never exceeded a cherry-red.

At a recent meeting of the Helvetic Academy of Sciences M. Dufour gave the principal results of an experimental inquiry into the variations of temperature which occur in diffusion of gases separated by a porous partition. He had studied, among other cases, those of hydrogen and air, of air and carbonic acid; and he distinguishes in these researches between diffusion at constant pressure and diffusion with varying pressure. A porous vessel containing the gas with slower diffusion (air or carbonic acid), and having a very sensitive thermometer applied to its inner surface, was placed in a larger and cloth-covered vessel, in which the other gas (hydrogen or air) was made to circulate. A glass tube through the stopper of the porous vessel communicated in some cases with the open air (constant pressure), and in others with a manometer. The thermometer was observed with a cathetometer. It appears that with constant pressure there is always elevation of temperature on the side of the entering diffusion, and lowering of temperature on the side where the diffusing gas issues from the partition. M. Dufour believes that this change of temperature is not produced throughout the whole gaseous mass, but only at the surface of the porous partition. He points out that at the side of entrance there is condensation, compression, and hence development of heat; while at the other, on the contrary, there is expansion of the gas, and so absorption of heat. With varying pressure the phenomenon is more complicated. The indications of the thermometer are shown by the annexed curve, in which the abscissæ are the times and the ordinates the temperatures.



GEOLOGY.

Stratigraphical Geology.—Dr. Dawson has alluded in a recent number of the "*Canadian Naturalist*" to the discussion which has reopened on the terms Cambrian and Silurian, and which originated in a difference of opinion between Sir Roderick Murchison and Professor Sedgwick. He agrees with Dr. Sterry Hunt that the Silurian system consists of two groups, which should have distinct names, and that the term Silurian should

be restricted to the Upper Silurian of Sir Roderick, whilst the term Siluro-Cambrian might be applied to the Lower Silurian rocks.

Capt. F. W. Hutton has communicated to the Geological Society a summary of the Tertiary formations of New Zealand, classifying them as follows:—

Pleistocene.	
Pliocene.	{ Newer Pliocene, or Whanganui group. Older Pliocene, or Lignite group.
Miocene.	{ Upper, or Arvaterre group. Lower, or Kanieri group.
Oligocene.	{ Upper, or Hawke's Bay group. Lower, or Waitewata group.
Eocene.	{ Upper, or Ototara group. Lower, or Brown Coal group.

Professor Hitchcock gives in the "Geological Magazine" a notice of the precise areas occupied by workable beds of coal in the United States, and he estimates the total to amount to 230,659 acres. This refers only to the coal of Carboniferous age, and excludes other beds of commercial value, which occur in the Triassic strata of Virginia, and in the Cretaceous rocks of the territories west of the Missouri River, in California, Alaska, &c.

Glacial Geology.—Mr. J. F. Campbell, the well-known author of "Frost and Fire," recently communicated to the Geological Society of London a memoir on the glaciation of Ireland. He stated that almost the entire surface of the country consists of glaciated rocks more or less weathered. The polished surfaces are covered in low grounds with drift—unstratified boulder clay being next to the rock, and above it sands and gravels and peat-bogs. The probable dimensions of the ice-engines which work on the surface of Ireland were shown by comparison of glaciers in Iceland, Norway, and elsewhere, with the Irish marks, which indicate ice of equal size. Horizontal grooves at 2000 feet above the sea were instanced as proving ice more than 2000 feet thick, which moved over Ireland into the Atlantic in a south-westerly direction. It was shown that the ice at its maximum probably extended from the Polar Basin to Cape Clear. Mr. Campbell concluded that the later denudation of Ireland was due to glacial and marine action, and that rivers and sub-aërial denudation have done little to obliterate the tool-marks of ice and the sea since the end of the last of a series of Glacial periods.

Origin of Lakes.—The glacial origin of rock-basins occupied by lakes, first promulgated by Professor Ramsay, has received the attention and corroboration of several American geologists. The theory was, however, combated by the Duke of Argyll in his recent Presidential address to the Geological Society of London, wherein he discussed the phenomena of denudation, referring especially to the influence of subterranean and other movements of the crust of the earth upon the denudation of its surface, and disputing the greatness of the denuding effects of glacial action.

The Rev. T. G. Bonney has likewise discussed the theory of the erosion of lake-basins by glaciers, testing it by the Lakes of Salzkammergut, in the North-Eastern Alps. He considered a far more probable explanation to be, that the greater lake-basins were parts of ordinary valleys, excavated by rain and rivers, the beds of which had undergone disturbances after the valley had assumed approximately its present contour. He showed that the lakes were in most cases maintained at their *present* level by drift; and that, while in a region so subject to slight disturbances as the Alps positive evidence for his theory would be almost impossible to obtain, no lake offered any against it, and one, the Königsee, was very favourable to it.

Signor Gastaldi, however, in describing the valley of the Lanzo and other Alpine valleys, pointed to the occurrence of large cirques at heights between 5000 and 10,000 feet. He noticed the various rocks in which these cirques were cut, and expressed his opinion that they are the beds formerly occupied by glaciers, the power of which to excavate even comparatively hard rocks, such as felspathic, amphibolite- and chlorite-schists, he considered to be proved.

Agricultural Geology and Geological Maps.—The relation between Agriculture and Geology is a significant fact, and has been brought prominently into notice in the description of many parts of Great Britain, in the "Journal of the Royal Agricultural Society," and in the "Bath and West of England Agricultural Society." Mr. Topley, F.G.S., has communicated to the first-mentioned Society a paper on the "Comparative Agriculture of England and Wales," in which he gives a table showing the percentage of each crop to the total acreage of each county, and then traces out the relations of geological structure and contour to Agriculture. Classifying the English counties according to their leading features, he remarks that the western part of the country contains the largest portion of high land, and that this higher western land is occupied by the older geological formations. The greatest rain-fall is over this area, and, speaking generally, over other districts the fall is in proportion to the height of the ground. Summer temperature is of great importance; this is highest over the eastern central district. Considered agriculturally, the western counties are characterised by their large acreage of grazing land, whilst in the eastern there is a high percentage of corn land. There is thus a general coincidence between geological structure, contour, climate, and agricultural products. These four classes are stated by Mr. Topley to be of importance in the order here given; each is controlled by the one that precedes it. Agriculture depends mainly on climate, climate mainly on contour, and contour mainly on geological structure.

Agriculture is of course closely related to Geology, in regard to soils, which depend so much upon the underlying rocks; but whilst such extensive systems of draining and manuring are now carried on, the character of the crops is not so dependent upon the natural soil as it used to be. Nevertheless, maps showing the superficial deposits, the gravels, drift clays, and loams, will be of great service to the agriculturist, and it can be little estimated—when glancing at our ordinary geological maps, where these deposits are omitted—what a vast difference their insertion makes. The publication of maps showing the superficial deposits has been commenced by the Geological Survey, in parts of Buckinghamshire, Hertfordshire, Middlesex, and Essex, included in their Sheets Nos. 1 to 7. These drifts or superficial deposits comprise the Boulder clay, and various gravels and brick-earths of different ages, also the clay-with-flints of the chalk districts.

Mr. Topley has given a sketch of the Agricultural Geology of the Weald in the last volume of the "Journal of the Royal Agricultural Society." His paper is accompanied by a coloured map showing the geology of the tract and the prevailing soils.

One of the recently-published maps of the Geological Survey of England is Sheet 64, which includes the county of Rutland and parts of Leicester- and Northampton-shires, and displays, in its geological structure, the Lias, the Lower and Middle Oolitic rocks, and a portion of the Fenland. This area has been surveyed by Mr. J. W. Judd, F.G.S., and until he gave his attention to the elucidation of the Lower Oolitic rocks of this much-neglected country much confusion existed about their classification. The conclusions at which he has arrived have been confirmed by Mr. Sharp, whose papers were referred to in our last report of Geological Progress.

Geological Diagrams.—Two Tables of British Strata, by Mr. H. W. Bristow, F.R.S., Director of the Geological Survey of England and Wales, have lately been published. The one is a classificatory table, showing the subdivision of the rocks and their local modifications: it contains also an account of the geological distribution of the different groups of life, by Mr. R. Etheridge, F.R.S. The other table is a coloured one, showing the relative thickness of the different geological systems, formations, and the minor subdivisions—a feature of great importance in a lecture- or school-diagram.

Mr. Topley, F.G.S., and Mr. J. B. Jordan have been constructing a series of geological models of England and Wales, on the scale of 4 miles to 1 inch horizontal, and 2000 feet to 1 inch vertical. There will be eighteen blocks, each about 25 inches by 17 inches in size, and they will show clearly the physical features and the geology of the country, which will be of great service

in illustrating the connection between the two,—also for military, engineering, and sanitary purposes they will be no doubt exceedingly useful.

CHEMICAL SCIENCE.

With regret we record the death of two distinguished chemists—Drs. Liebig and Bence Jones. Justus Liebig was born in the small German town of Darmstadt, on May 13, 1803, and educated in Bonn and Erlangen. He was originally intended for a pharmacist, but having found the means of visiting Paris, and passing some time in the laboratories of the great French chemists who flourished in the year 1823, and, having achieved a success as a chemist, he was at once enrolled by Humboldt in the ranks of the German professoriat, being in 1826 nominated Professor in Ordinary in the University of Giessen, after having for the two preceding years held office as Extraordinary Professor in the same University. Liebig left Giessen in the year 1852, and went to Munich, where he became Professor of Chemistry in the University and President of the Academy of Sciences. In 1845 he had been created a Baron. He died at Munich on the 18th of April. At a meeting of the German Chemical Society, held in Berlin, on April 28th, it was resolved to erect a statue in honour of Liebig, and to invite his pupils, friends, and chemists of all nations to contribute towards the funds necessary for that object. Drs. Warren de la Rue, Frankland, Gilbert, Odling, Stenhouse, and Williamson are members of the Committee, and communications and subscriptions may be sent to Dr. Hugo Müller, 110, Bunhill Row, E.C. The distinguished secretary of the Royal Institution, Dr. H. Bence Jones, died on the 20th of the same month after a long, and latterly, severe illness. His treatise on the early history of the Royal Institution, and his valuable biography of Faraday, are amongst the latest of his works. A movement which was set on foot to get up a testimonial to Dr. Jones, will, in agreement with his own wishes, take the form of a bust to be placed in the Royal Institution.

Curious results followed some of the experiments made upon charred papers and documents, and the examination of books in safes which proved worthless in the great fire at Boston. It was found that what paper makers call poor paper, paper considerably "clayed," stood the test best. Parchment paper, used for bonds and legal documents, shrivelled up exceedingly, and the print blistered so that it could be read when writing was illegible. So it was with the engraved work on notes. The gilding on the account books burned and charred showed out as bright and as clear as when the books were new, which brings up the question if to introduce gilt-edged account books would not be well, on the ground that the gilt would stay the passage of fire to the pages within. Books crammed into a safe so that it was difficult to get them out, suffered considerably less than those that were set in loosely, and in some cases came out from safes, in which everything else was worthless, so far preserved that the figures on their pages could be deciphered. With charred papers, which could not be made transparent by any light whatever used, it was found, after the employment of vitriol, oxalic acid, chalk, glycerine, and other things, that anything that moistened them to a certain stage—to which it was delicate work to get and not to pass—made the lines, words, and figures legible through a magnifying glass. It has been the almost universal experience that lead pencil marks show out all right where ink marks cannot be distinguished. The success of the use of photography has already been noted.

Mr. Elihu Thompson has made the observation that tin-foil, if wrapped about a few crystals of chlorate of potassa, can be made to detonate loudly upon being struck smartly with a hammer upon an anvil, or in a mortar; the phenomenon being precisely analogous to the well-known experiment of triturating sulphur and the chlorate.

In order to ascertain whether ground coffee has been mixed with either roasted corn or amylaceous substances generally, it is only necessary to treat

the powder, first with dilute caustic potassa, and, after filtration and addition of a large quantity of pure water, a solution of iodine is added, whereby the starch is detected.

TECHNOLOGY.

The Boston "Journal of Chemistry" gives the following interesting account of the way in which the natives of East India clean silver articles :—Cut some juicy lemons in slices ; with these rub any large silver or plated article briskly, and leave it hidden by the slices in a pan for a few hours. For delicate jewellery, the Indians cut a large lime nearly in half, and insert the ornament ; they then close up the halves tightly, and put it away for a few hours. The articles are then to be removed, rinsed in two or three waters, and consigned to a saucepan of nearly boiling soapsuds, well stirred about, taken out, again brushed, rinsed, and finally dried on a metal plate over hot water, finishing the process by a little rub of wash-leather (if smooth work). For very old neglected or corroded silver, dip the article, with a slow stirring motion, in a rather weak solution of cyanide of potassium ; but this process requires care and practice, as it is by dissolving off the dirty silver you obtain the effect. Green tamarind pods (oxalate of potash) are greater detergents of gold and silver articles than lemons, and are much more employed by the artisan for removal of oxides and fire-marks.

According to P. Rast so-called German silver may be applied to soldering steel to iron and iron to copper. Borax should be used as a flux, and the German silver granulated as is done for hard brass solder.

Iron may be gilded by first applying sodium amalgam to the iron, which is thereby readily coated with mercury. Next a concentrated solution of chloride of gold is applied to the mercurially coated surface ; and lastly, the object is strongly heated, either in a muffle or in the flame of an enameller's lamp.

Common mercurial ointment has been found remarkably efficacious in preventing the formation of rust upon articles of iron and steel, such as gun-barrels.

* * The article in No. xxxviii. of the "Quarterly Journal of Science" on "Atmospheric Life Germs" was written by Mr. W. N. HARTLEY, of King's College, whose name was inadvertently omitted.
